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CIVIL AND MECHANICAL ENGINEERING.

For the Journal of the Franklin Institute.

The Preservation of Wood in Damp and Wet Situations. By H. W. Lewis, University of Michigan.

(Concluded from page 223.)

In 1846, eighty thousand sleepers of the most perishable woods, impregnated, by Boucherie's process, with sulphate of copper, were laid down on French railways. After nine years exposure, they were found as perfect as when laid.* This experiment was so satisfactory that most of the railways of that empire at once adopted the system. We would suggest washing out the sap with water, which would not coagulate its albumen. The solution would appropriately follow.

Both of the last named processes are comparatively cheap. The manufacturing companies of Lowell, Mass., have an establishment for "Burnettizing" timber,† in which they prepare sticks 50 feet in length. Under a pressure of 125 pounds per square inch, they inject from two to eight ounces of the salt into each cubic foot of wood. The cost, in 1861, was from $5 to $6 per 1000 feet, board measure.‡ Boucherie's method must be still cheaper. It costs less than creosoting by one shilling per sleeper.§

An American engineer, Mr. Hewson, for injecting railroad sleepers,

* *Jour. of the Frank. Inst.*, vol. xxxii., pp. 2, 3. † *New American Cyclopædia.*

‡ The Philadelphia, Wilmington and Baltimore Railroad Company have used the process since 1860 with complete success. The Union Pacific Railroad Company have recently erected a large building for this purpose. Their cylinder is 75 feet long, 61 inches in diameter, and capable of holding 250 ties. They "Burnettize" two batches per day. *Report on Pacific Railroad* by Col. Simpson, 1865.

§ *Jour. Frank. Inst.*, vol. xxxii., pp. 2, 3.

proposes a vat deep enough for the timbers to stand upright in. The pressure of the surrounding solution upon the lower ends of the sticks will, he thinks, force the air out at their upper extremities, kept just above the surface of the solution, after which the latter will rise and impregnate the wood. In 1859, he estimated chloride of zinc at 9 cents per pound, sulphate of copper at 14 cents per pound, and pyrolignite of of iron at 23 cents per gallon. He found the cost of impregnating a railway tie with sufficient of those salts to prevent decay, to be—for the chloride of zinc 2·8 cents, for blue vitriol 3·24 cents, for pyrolignite of iron 7·5 cents.*

Among the numerous other preservative compounds, may be mentioned Le Gras' mixture† of a double salt of manganese and lime (or zinc) with creosote, Payne's solutions‡ of sulphate of iron and muriate of lime, forming by double decomposition an insoluble sulphate of lime among the wood fibres, Margary's solution of acetate of copper, and Ransome's liquid silicate of potassa.§ Payne's process met with some favor. But neither of the last are of appreciable value.

Vessel owners had long ago observed that those ships which have early sailed with cargoes of salt are not attacked by dry rot. Indeed, several instances are well attested of vessels, whose interiors were lined with fungi, having all traces of the plant destroyed by accidental or intentional sinking in the sea. Acting on such hints, a trader of Boston salted his ships with 500 bushels of the chloride, disposed as an interior lining, adding 100 bushels at the end of two years.‖ Such an addition of dead weight, (35,000 pounds in this case,) is sufficient objection to a procedure which has other great disadvantages.

The unpleasant odor of creosote is greatly against its use upon lumber for dwellings, and Bethell's process, therefore, is not described here, although the most satisfactory known. Pyrolignite of iron is offensive and also highly inflammable. The affinity of the chlorides for water keeps the structure into which they are introduced wet; besides, they corrode the iron-work. Sulphate of copper is free from these objections, and is, at present, cheaper than the chlorides.¶ Therefore, *for protecting wooden structures against dry rot* in damp situations, like mines, vaults, and the basements of buildings, *sulphate of copper seems preferable, and Hewson's or Boucherie's method of injecting it cheaper and more expedient, according as the timber is short or long.*

II. *Wood alternately wet and dry.*—The surface of all timber ex-

* *Jour. Frank. Inst.*, vol. xxvii., page 8. † *Civ. Eng. Jour.*, vol. xviii., p. 20.

‡ Ibid., vol.vi., p. 207.

§ Fifty pounds of carbonate of potassa are dissolved in water, and a little lime is added to neutralize any free acid. 100 pounds of flints are added and the whole exposed 10 or 12 hours to a temperature of 300° F. This solution is evaporated to 1·500 at 60°.—*Civil Engineer's Journal*, vol. ix.

‖ *American Journal of Science*, vol. ii., p. 17.

¶ Price of sulphate of copper per pound 11¾ and 12 cents; sulphate of zinc 8 and 12 cents; chloride of zinc $1·60 and $1·75; chloride of mercury, $1·08 and $1·10. —From *Druggist's Circular*, June ,1866.

The price paid for chloride of zinc by the Michigan Central Railroad Company, two years ago, was 6 cents per pound.—*Auditor's Office, M. C. RR. Co.*

posed to alternations of wetness and dryness, gradually wastes away, becoming dark-colored or black. This is really a slow combustion, but is commonly called wet rot, or simply rot. Other conditions being the same, the most dense and resinous woods longest resist decomposition. Hence the superior durability of the heart-wood, in which the pores have been partly filled with lignine, over the open sap-wood, and of dense oak and lignum-vitæ over light poplar and willow. Hence, too, the longer preservation of the pitch-pine and resinous "jarrah" of the East, as compared with non-resinous beech and ash.

Density and resinousness exclude water. Therefore our preservatives should increase those qualities in the timber. Fixed oils fill up the pores and increase the density. Staves from oil barrels and timbers from whaling ships are very durable. The essential oils resinify, and furnish an impermeable coating. But pitch or dead oil possesses advantages over all known substances for the protection of wood against changes of humidity. According to Professor Letheby,* dead oil, 1st, coagulates albuminous substances; 2d, absorbs and appropriates the oxygen in the pores, and so protects from eremacausis; 3d, resinifies in the pores of the wood, and thus shuts out both air and moisture; and, 4th, acts as a poison to lower forms of animal and vegetable life, and so protects the wood from all parasites. All these properties specially fit it for impregnating timber exposed to alternations of wet and dry states, as, indeed, some of them do, for situations damp and situations constantly wet. Dead oil is distilled from coal-tar, of which it constitutes about ·30, and boils between 390° and 470° Fahr. Its antiseptic quality resides in the creosote it contains. One of the components of the latter, carbolic acid (phenic acid, phenol) C_{12} H_6 O_2,† the most powerful antiseptic known, is able at once to arrest the decay of every kind of organic matter.‡ Prof. Letheby estimates this acid at ½ to 6 per cent. of the oil. Chrysilic acid C_{14} H_8 O_2, the homologue of carbolic acid, and the other component of creosote, is not known to possess preservative properties.

Bethell's process§ subjects the timber and dead oil, enclosed in huge

* *Civil Engineer's Journal*, vol. xxiii., page 216.

† "Creosote from coal undoubtedly contains two homologous bodies, C_{12} H_6 O_2 and C_{14} H_8 O_2, the first being carbolic and the second cresylic acid."—Ure's *Dict. of Arts, Manu., and Mines*, vol. ii, p. 623.

‡ "I have ascertained that adding one part of carbolic acid to five thousand parts of a strong solution of glue will keep it perfectly sweet for at least two years. . . . . Hides and skins, immersed in a solution of one part of carbolic acid to fifty parts of water, for twenty-four hours, dry in air and remain quite sweet."—Prof. Crace Calvert, *Ann. Sc. Discov.*, 1865, p. 55.

"Carbolic acid is sufficiently soluble in water for the solution to possess the power of arresting or preventing spontaneous fermentation. Saturated solutions act on animals and plants as a virulent poison, though containing only five per cent. of the acid."—*Civ. Eng. Jour.*, vol. xxii., p. 216.

"Parasitic and other worms are instantly killed by a solution containing only one-half per cent. of acid, or by exposure to the air containing a small portion of the acid . . . . . By examining the action on a leaf, we find the albumen is coagulated. All animals with a naked skin, and those that live in water, die sooner than those that live in air and have a solid envelope."—Dr. I. Lemaire *Ann. Sc. Discov.*, 1865, p. 238.

§ Ronald and Richardson's *Technology*, p. 739.

iron tanks, to a pressure varying between 100 and 200 pounds per square inch, about twelve hours. From eight to twelve pounds of oil are thus injected into each cubic foot of wood. Lumber thus prepared is not affected by exposure to air and water, and requires no painting.* A large number of English railway companies have already adopted the system.† Eight pounds of oil per cubic foot is sufficient for railway sleepers.‡

The cost of "creosoting," as this process is sometimes called, was given in 1855, by Ronald and Richardson, at somewhat less than four pence per cubic foot,§ in England. At one shilling per gallon,‖ the price at which dead oil was obtainable in England in 1863, four pence per cubic foot would, we presume, be sufficient.

A process recently patented, and described in the *Scientific American*, February 17, 1866, proposes to introduce highly heated oleaginous vapors among the timber, confined in an iron tank. The patentee¶ hopes, that as fast as the moisture is expelled from the wood, the vapor will take its place. Whether this substitution would not soon arrest itself, should it even commence, is in our mind a debatable question.

While an external application of coal-tar promotes the preservation of dry timber, nothing can more rapidly hasten decay than such a coating upon the surface of green wood. But this mistake is often made, and dry rot, instead of wet rot, does the work of destruction.** The reason must appear from what has been said on dry rot. Carbonizing the surface also increases the durability of dry, but promotes the decay of wet, timber. Farmers very often resort to one of the latter methods for the preservation of their fence-posts. Unless they discriminate between green and seasoned timber, these operations will prove injurious instead of beneficial.

In this connection, we remark, that inverting a post from the position in which it grew, is by some supposed to retard decay. According to the President of the "Northern Architect's Association," England, "the *valves*" close against moisture ascending through the ducts from the earth into the post.†† But, according to Gray, thin places only separate contiguous ducts. Fluids can pass through them in *one* direction as well as in the *other*. When age obliterates these thin mediums, nothing opposes the flow upward or downward. Furthermore, the passage of fluids through wood is not confined to ducts: it takes

* Ure's *Dict. of Manu. and Mines.*

† The Great Western, North-Eastern, Bristol and Exeter, Stockton and Darlington, Manchester and Birmingham, and London and Birmingham.—Ure's *Dict. of Manu. and Mines.*

‡ *Jour. Frank. Inst.*, vol. xliv., p. 275. § *Chemical Technology*, p. 737.

‖ Dr. J. G. Ashby in the *London Mechanic's Magazine*, July, 1862. He says, "Crude carbolic acid can be obtained for one shilling," but undoubtedly means dead oil.

¶ Louis S. Robbins, New York City.

** According to Col. Berrien, the Michigan Central Railroad bridge, at Niles, was painted, *before seasoning*, with "Ohio fire-proof paint," forming a glazed surface. About five years after, it was so badly dry rotted as to require rebuilding.

†† The *Builder* for 1866, p. 79.

place on all sides of them as well. In face of these facts, very careful experiments will be requisite to convince us that a post is more durable in the inverted than in the normal position.

III. *Timber constantly wet in salt water.*—We have not to guard against decay when timber is in this situation. Teredo navalis, a mollusk of the family Tubicolària, Lam., soon reduces to ruins any unprotected submarine construction of common woods. I quote from a paper read before the "Institute of Civil Engineers," England, illustrating the ravages of this animal:

"The sheeting at Southend pier extended from the mud to eight feet above low-water mark. The worm destroyed the timber from two feet below the surface of the mud to eight feet above low-water mark, spring-tide; and out of 38 fir-timber piles and various oak-timber piles, not one remained perfect after being up only three years."* Specimens of wood, taken from a vessel that had made a voyage to Africa, are in the museum, and show how this rapid destruction is effected.

None of our native timbers are exempt from these inroads. Robert Stephenson, at Bell Rock, between 1814 and 1843,† found that greenheart oak, beef-wood, and bullet-tree were not perforated, and teak but slightly so. Later experiments show that the "jarrah" of the East, also, is not attacked.‡ The cost of those woods obliges us to resort to artificial protection.

The teredo never *perforates* below the surface of the sea-bottom,§ and probably does little injury above low-water mark. Its minute orifice, bored across the grain of the timber, enlarges inwards to the size of the finger, and soon becomes parallel to the fibre. The smooth circular perforation is lined throughout with a thin shell which is sometimes the only material separating the adjacent cells. The borings undoubtedly constitute the animal's food, portions of woody fibre having been found in its body.‖ While upon the surface only the projecting siphuncles indicate the presence of the teredo, the wood within may be absolutely honey-combed with tubes from one to four inches in length.

It was naturally supposed that poisoning the timber would poison or drive away the teredo, but Kyan's, and all other processes employing solutions of the salts of metals or alkaline earths, signally failed. This, however, is not surprising. The constant motion of seawater soon dilutes and washes away the small quantity of soluble poison with which the wood has been injected. If any albuminate of a metallic base still remains in the wood, the poisonous properties of the injection have been destroyed by the combination. Moreover, the lower vertebrates are unaffected by poisons which kill the mammals. Indeed, it is now known that certain of the lower forms of animal life live and even fatten on such deadly agents as arsenic.¶

* *Civ. Eng. Jour.*, vol. xii., page 382.

† Ibid., vol. xx., p. 16.

‡ The *Builder* for 1862, p. 511.

§ *Civ. Eng. Jour.*, vol. xx., p.

‖ Ibid., vol. xii., p. 382. Also *Dict. Univer. d'His. Natur.*, tome xii.

¶ *British and Foreign Medical Review.*

Coatings of paint or pitch are too rapidly worn away by marine action to be of much use, but timber, thoroughly creosoted with ten *pounds of dead oil per cubic foot, is perfectly protected against teredo* navalis. All recent authorites agree upon this point. In one instance, well authenticated, the mollusk reached the impregnated heart-wood by a hole carelessly made through the injected exterior. The animal pierced the heart-wood in several directions, but turned aside from the creosoted zone.* The process and cost of "creosoting" have already been discussed.

A second destroyer of submarine wooden constructions is limnoria terebrans, (or L. perforata, Leach,) a mollusk of the family Assellotes, Leach, resembling the sow-bug. It pierces the hardest woods with cylindrical, perfectly smooth, winding holes, $\frac{1}{20}$th to $\frac{1}{15}$th of an inch in diameter, and about two inches deep†. From ligneous matter having been found in its viscera, some have concluded that the limnoria feeds on the wood, but since other mollusks of the same genius, Pholas, bore and destroy stone-work, the perforation may serve only for the animal's dwelling. The limnoria seems to prefer tender woods, but the hardest do not escape. Green-heart oak is the only known wood which is not speedily destroyed.‡ At the harbor of Lowestoft, England, square fourteen inch piles were, in three years, eaten down to four inches square.§

While all agree that no preparation, if we except dead oil, has repelled the limnoria, an eminent English engineer has cited three cases in which that agent afforded no protection.‖

We do not find that timber impregnated with water-glass has been tested against this subtle foe. The experiment is certainly worthy of a trial.

A mechanical protection is found in thickly studding the surface of the timber with broad-headed iron nails. This method has proved successful.¶ Oxydation rapidly fills the interstices between the heads, and the outside of the timber becomes coated with an impenetrable crust, so that the presence of the nails is hardly necessary.

In conclusion, we cannot but express surprise that so little is known in this country concerning preservative processes. Their employment seems to excite very little interest, and the very few works where they are being tested attract hardly any attention. Those railroads which have suspended their use assign no reasons, and those upon which the timber is injected publish no reports concerning the advantages of their particular methods. Even the National Works, upon which Kyan's process was formerly employed, have laid it aside, and now subject lumber to dampness and alternations of wetness and dryness, without any preparation beyond seasoning. When sleepers cost fifty cents and creosoting thirty cents each, it is cheaper to hire money at seven per cent., compound interest, than to lay new sleepers at the end of seven years. Allowing any ordinary price for the removal of the old and laying down the new ties, the advantage of using Bethell's process

* *Civ. Eng. Jour.*, vol. xii., page 191.

† *Dict. Univer. d'His. Natur.*

‡ *Civ. Eng. Jour.*, vol. xxv., p. 206.

§ Ibid., vol. xvi., p. 76.

‖ Ibid., vol. xxv. p. 206.

¶ Ibid., vol. xii., p. 382.

seems evident. If some cheaper method will produce the same effects, the folly of neglecting *all* means seeking to increase the durability of the material is still more palpable.

Complete and reliable reports upon the preservation of the various species of woods experimented upon in this country are greatly needed, and we hope they may shortly appear.

For the Journal of the Franklin Institute.

Limes, Cements, Mortars, and Concretes. By CHAS. H. HASWELL, C.E., New York.

(Continued from volume l., page 175.)

TABLES *showing the Resistance to Transverse Strains of Concretes, Cements, Mortars, Puzzuolana, and Trass.*

Reduced to a bar 1 inch square and 1 foot in length. Supported at both ends.

$\frac{2}{3}\frac{l\,w}{4\,b\,d^2} = v$ per square inch of section; represents value for general use, being $\frac{2}{3}$ of ultimate breaking strain.

EXPERIMENTS OF VOISIN, 1857.

MORTAR.			CONCRETE.				
One volume of sand.			One volume of pebbles.		Calculated value of v.		
Cement.	Water.	Volume produced.	Mortar.	Volume produced.	10 days.	20 days.	60 days.
1	·62	1·69	1	1·56	2·3	2 3	2·9
			½	1·03	1·7	2·8	3·2
			⅓	1·	1 8	2 3	3·1
			¼	1·	1·	1·4	1·
½	·43	1·24	1	1·45	1·6	1·9	2·7
			⅔	1·11	1 6	2·	2 1
			½	1·	1·	1·4	1·9
⅓	·38	1·12	1	1·4	·86	·95	·91
			⅔	1·11	·68	·98	1·3
			½	1·03	·58	·76	1·2
¼	·35	1·05	1	1·4	·48	·74	1·
			⅔	1·14	·32	·61	·92
			½	1·01	·35	·51	·85
⅕	·34	1·	1	1·45	·3	·65	·83
			⅔	1·13	·24	·48	·09
			½	1·03	·44	·43	·65
⅙	·32	·96	1	1·45	·41	·41	·81
			⅔	1·13	·28	·42	·72
			½	1·03	·36	·38	·79

EXPERIMENTS OF GEN. TOTTEN, 1837.

CONCRETE.*	MORTAR. Cement 1 · Sand 2·0 Lime 2·0	Cement 1 · Sand 3·5 Lime 2·0	Cement 1 · Sand 3·5 Lime 2·25	Cement 1 · Sand 1 · Lime 1·0
	v.	v.	v.	v.
Granite 1 / Mortar 1	2·9	2·4	1·6	2·3
Granite 1 / Mortar 2	2·4	2·9	2·9	2·4
Brick† 1 / Mortar 1	1·9	1·2	.....	2·4
Brick 1 / Mortar 2	1·6	2·9	1·6	2·6
Gravel 1 / Mortar 1	·6	·6	·7	·7
Gravel 1 / Mortar 2	1·4	2·4	1·5	·7
Stone / Gravel	1·9	1·	1·1	·6
Brick / Gravel	·9	1·4	1·6	1·6

* The granite, bricks, &c., were broken into fragments or spalls of the required size.

† Brick gravel gave 50 per cent. greater resistance than the fragments.

EXPERIMENTS OF GEN. GILMORE.

MATERIALS.	CEMENTS AND MIXTURES.	Calculated value of v.
Rosendale, 95 days	Pure	7·
	Cement 1 / Lime ¼	6·7
	Cement 1 / Lime ½	5·6
	Cement 1 / Lime ¼	5·1
	Cement 1 / Lime 1	3·9
James River, 59 days	Cement 4· values / Water 2·6 "	1·9
	Cement 4· " / Water 1·4 "	3·4*
Rosendale, (Hoffman,) 320 days	Stiff paste	4·4*
	Thin "	4·8*
Delafield and Baxter	Stiff "	6·*

* All except the first were submitted to a pressure of 32 lbs. per square inch.

MATERIALS.	CEMENTS AND MIXTURES.	Calculated value of v.
Portland, (Eng.,) 320 days	Pure cement	10·6
	Cement 1, Sand 1	8·7
	Cement 1, Sand 2	6·6
Roman, (Eng.,) 100 days	Cement 1, Sand 1	4·
Portland Pure, (Eng.,) 270 days	Cement 1, Sand 1	12·5
	Cement 1, Sand 2	13·
		8·5
High Falls, (N. Y.,) 270 days	Pure	11·3
James River	Cement 1, Sand 1, Fresh	5·9
		4·3

NOTE.—When the paste is not subjected to compression during setting, a thin paste produces about as strong a mortar as a stiff one.

CEMENT.	Calculated value of v.		
	Pure.	Cement 1. Sand... 1.	Cement 1. Sand... 2.
Portland, English, (artificial)	10·5	8·6	6·5
Cumberland, Md	6·5	6·3	3·8
Newark and Rosendale	5·8	3·8	3·4
Round Top, Md		4·1	
Utica, Ill	5·1	1·2	3·8
Shepherdstown, Va	5·1	4·2	3·1
Akron, New York	5·2	4·4	4·1
Brighton and Rosendale	4·9	3·8	3·4
Sandusky, Ohio	3·8	3·2	
James River, Va		4·2	4.4
Rosendale, Lamenceuth		6·2	
Hoffman	5·8	4·1	
Lawrence	5·3		
Remington, Conn	6·5	4·8	3·4

EXPERIMENTS OF GEN. TREUSSART.

PUZZUOLANA AND TRASS—MORTAR.			Calculated value of v.
Strasburgh	Lime 1, Sand 1, Trass 1	5 days	2·8
	Lime 1, Trass 2	4 "	2·3
	Lime 1, Sand 1, Puzzuolana 1	4 "	3·4

PUZZUOLANA AND TRASS—MORTAR.			Calculated value of v.
White Marble	Lime 1, Sand 1, Trass 1	5 days	2·1
	Lime 1, Sand 1, Puzzuolana 1	4 "	2·7
Strasburgh	Lime paste 1, Puzzuolana 2½	5 "	3·8
	Lime paste 1, Trass 2	8 "	3·1

Portland cement, 4 months	21·3
Roman " 4 "	14·8
Fire brick beam,* loaded partly along the centre	2·1
Cement paste, 95 days	13·8
" " 1, lime paste ½	13·6
" " 1, " " ⅓	11·3
" " 1, " " ¼	7·8
" " 1, " " 1	7·9
" " ¾, " " 1	5·
" " ½, " " 1	4·2

* Broke through the bricks.

Tensile Resistance of various Cements, Mortars, and Masonry per square inch.

EXPERIMENTS OF VICAT AND CHATONEY AT CHERBOURG, GEN. GILMORE, CRYSTAL PALACE, LONDON, &C.

MATERIALS AND MIXTURES.	Ultimate resistance.
Boulogne, 100 parts, water 50	112
90 days, 100 parts, water 50	52
Boulogne, 1 year, Portland, (natural)	675
English, 1 year, Portland, (artificial)	462
Roman, 1 year, from Septaria	191
" 42 days, cement 1, sand 1	284
" " " 1, " 2	199
" " " 1, " 3	166
Portland, " " 1, " 1	142
" " " 1, " 2	113
" " " 1, " 3	192
" 15 days, " 6, water 4	134
" 45 " " " "	207
" 135 " " " "	233
" English, 320 days, pure	1152
" " " cement 1, sand 1	948
" " " " 1, " 2	713
Roman, " 100 days, " 1, " 1	439
Portland, 45 days, pure and mixed, stiff	206
" English, pure, 1 month	393
" " " 6 months	424
Stone masonry, Roman cement, 5 months	77

BRICK AND GRANITE MASONRY, 320 DAYS.		
Cement, Delafield and Baxter	Pure	68·56
	Cement 4, Sand 1	68·5
	Cement 5, Siftings 1	79·87
	Cement 1, Siftings 2	74·5
" Lawrence Co	Pure	87·37
	Pure	53·68
" James River	Cement 4, Sand 1	62·
" Newark Lime and Cement Co	Pure	93·25
	Cement 1, Sand 2	89·62
" Brighton and Rosendale	Pure	80·25
" Newark and Rosendale	Pure	75·81
" Pure upon bricks		31·
" 1, sand 1 pure upon bricks		16·
" 1, " 3 " "		7·
" pure upon granite		27·
" 1, water ½		20·
" 1, " 42		27·
" pure upon bricks with mortar in the joint, mean		6·
" " " without mortar, mean		45·
Lime paste 1, Sand 3	upon bricks	6·
Lime paste 1, Sand 2	" "	4·13
Lime paste 1, Sand 3, Cement paste 5	" "	11·41

TABLE SHOWING THE RESISTANCE TO CRUSHING STRAIN OF CEMENTS, STONE, &C., (CRYSTAL PALACE, LONDON.)

MATERIAL.	Ultimate pressure per square inch.
Portland cement, area 1, heigth 1	1680
" " 1, Sand 1	1244
Cement 1, Sand 4	1244
Roman cement, pure	342

Deductions.—1st. Particles of unground cement exceeding $\frac{1}{60}$ inch in diameter may be allowed in cement paste without sand to the extent of 50 per cent. of the whole, without detriment to its adhesive or cohesive properties, while a corresponding proportion of sand injures the strength of the mortars in these respects about 40 per cent.

2d. That when these unground particles exist in the cement paste to the extent of 66 per cent. of the whole, the adhesive strength is diminished about 28 per cent. For a corresponding proportion of sand the diminution is 68 per cent.

3d. The addition of siftings exercises a less injurious effect upon the cohesive than upon the adhesive property of cement. The converse is true when sand, instead of siftings, is used.

4th. In all the mixtures with siftings, even when the latter amounted to 66 per cent of the whole, the cohesive strength of the mortars exceeded its adhesion to the bricks. The same results appear to exist when the siftings are replaced by sand, until the volume of the latter exceeds 20 per cent of the whole, after which the adhesion exceeds the cohesion.

5th. At the age of 320 days (and perhaps considerably within that period) the cohesive strength of pure cement mortar exceeds that of Croton front bricks. The converse is true when the mortar contains 50 per cent. or more of sand.

6th. When cement is to be used without sand, as may be the case when *grouting* is resorted to, or when old walls are to be repaired by injections of thin paste, there is no advantage in having it ground to an impalpable powder.

7th. For economy it is customary to add lime to cement mortars, and this may be done to a considerable extent when in positions where hydraulic activity and strength are not required in an eminent degree.

Slaking.—The volume of water required to slake lime will vary with limes from 2·5 to 3 times the volume of the lime, (quicklime,) and it is important that all the water required to reduce the lime to a proper consistency should be given to it before the temperature of the water first given becomes sensibly elevated.

Immediately upon the lime being provided with the requisite volume of water, it should be covered, in order to confine the heat, and it should not be stirred whilst slaking. When the paste is required for *grouting* or *whitewashing*, the water required should be given at once, and in larger volume than when the paste is required for mortar, and when slaked the mass should be transferred to tight casks to prevent the loss of water. When the character of the limes, as with those of hydraulic energy, will not readily reduce, their reduction, which is an indispensable condition, must be aided by mechanical means, as a mortar mill.

TABLE SHOWING THE COMPARATIVE VOLUMES OF LIME AND SLAKED LIME.

WEIGHT OF VOLUME OF LIME 5 POUNDS.

LIME.	Volume—			Ratio of increase.	
	Before slaking.	After slaking.	Of water.	Weight.	Volume.
	Cub. in.	Cub. in.	Cub. in.		
Rockland, lump.....	91·2	224·2	.....	2·24	2·46
Sing Sing, lump.....	87·4	227·	210·	2·22	2·61
Rondout, ground.....	110·2	222·3	195·7	2·12	2·
Glenn Falls, lump....	93·1	304·	279·3	2·7	3·26
" by immersion	91·2	202·8	181·5	2·1	2·54

The process here given is termed *drowning*. When the lime is retained in a barrel, or like instrument, immersed in water, and then withdrawn before reduction occurs, it is termed *immersion*, and when it is reduced by being exposed to the atmosphere, and gradually absorbing moisture therefrom, it is termed *air-slaked*.

Bricks should be well wetted before use. *Sea sand* should not be used in the composition of mortar, as it contains salt and its grains are round, being worn by attrition, and consequently having less tenacity than sharp-edged grains.

Fine Clay.—The fusibility of clay arises from the presence of impurities, such as lime, iron, and manganese. These may be removed by steeping the clay in hot muriatic acid, then washing it with water. Crucibles from common clay may be made in this manner.

Pisé is made of clay or earth rammed in layers of from 3 to 4 inches in depth. In moist climates it is necessary to protect the external surface of a wall constructed in this manner with a coat of mortar.

Asphalt Composition.—Mineral pitch 1 part, bitumen 11, powdered stone, or wood ashes, 7 parts.

2. Ashes 2 parts, clay 3 parts, and sand 1 part, mixed with a little oil, makes a very fine and durable cement, suitable for external use.

Mastic.—Pulverized burnt clay 93 parts, litharge ground very fine 7 parts, mixed with a sufficient quantity of pure linseed oil.

3. Silicious sand 14, pulverized calcareous stone 14, litharge $\frac{1}{14}$ of the weight of the sand and stone, and linseed oil $\frac{1}{7}$ of the total weight of the materials.

The powders to be well dried in an oven, and the surface upon which it is to be applied must be saturated with oil.

4. *For Roads.*—Bitumen 16,875 parts, asphaltum 225 parts, oil of resin 6·25 parts, and sand 135 parts. Thickness, from $1\frac{1}{4}$ to $1\frac{3}{8}$ inches.

Asphaltum 55 lbs. and gravel 28·7 lbs. will cover an area of 10·75 square feet.

Notes by General Gilmore, U. S. A.—All the lime necessary for any required quantity or "batch" of mortar should be slaked at least one day before it is mixed with the sand.

All the water required to slake the lime should be poured on at one time, the lime should be submerged, and the mass should then be covered with a tarpaulin or canvas, and allowed to remain undisturbed for a period of 24 hours.

The ingredients should be thoroughly mixed, and then heaped for use as required.

Recent experiments have developed that most American cements will sustain, without any great loss of strength, a dose of lime paste equal to that of the cement paste, whilst a dose equal to $\frac{1}{2}$ to $\frac{3}{4}$ the volume of current paste may be safely added to any Rosendale cement without producing any essential deterioration of the quality of the mortar. Neither is the hydraulic activity of the mortars so far impaired by this limited addition of lime paste as to render them unsuited for concrete under water, or other submarine masonry. By the

use of lime is secured the double advantages of slow setting and economy.

Pointing Mortar is composed of a paste of finely ground cement and clean sharp silicious sand, in such proportions that the volume of cement paste is slightly in excess of the volume of voids or spaces in the sand. The volume of sand varies from $2\frac{1}{2}$ to $2\frac{3}{4}$ that of the cement paste, or by weight, 1 of cement powder to 3 to $3\frac{1}{2}$ of sand. The mixture should be made under shelter, and in quantities not exceeding from 2 to 3 pints at a time.

Before pointing, the joints should be reamed, and in close masonry they must be open to $\frac{3}{16}$ of an inch, then thoroughly saturated with water and maintained in a condition that they will neither absorb water from the mortar, or impart any to it. Masonry should not be allowed to dry rapidly after pointing, but it should be well driven in by the aid of a caulking iron and hammer. This operation should be repeated until the joint is entirely full.

In the pointing of rubble masonry the same general directions are to be observed.

Notes by General Totton, U. S. A.—240 lbs. lime = 1 cask, will make from 7·8 to 8·15 cubic feet of stiff paste.

308* lbs. of finely ground cement will make from 3·7 to 3·8 cubic feet of stiff paste. 79 to 83 lbs. of cement powder will make 1 cubic foot of stiff paste.

1 cubic foot of dry cement powder, measured when loose, will measure ·78 to ·8 cubic foot when packed, (as at a manufactory.)

100 yards of lath and plaster work, with wages of mason at $1·75 per day, and Rockland lime at $1 per cask, cost, respectively—

3 coats hard finish work	$25·50
2 coats slipped work	19 95

* 300 lbs. net is the standard barrel, but it usually weighs 308 lbs.

For the Journal of the Franklin Institute.

A new Marine Signal Light. By R. H. Thurston, 1st Asst. Eng., United States Navy.

The metal magnesium, to which so much attention has been drawn lately by its remarkable illuminating power, was discovered by Sir Humphrey Davy at about the same time that he discovered the metals of the alkalies, and by a similar method. It is a white metal, quite similar in appearance to silver, but remarkable for its lightness, a cubic inch weighing about an ounce. It melts and volatilizes, when protected from the atmosphere, at nearly the same temperature as zinc, but a fine wire or thin ribbon of it, exposed to high temperature in air, takes fire and burns with a bluish-white light of dazzling brilliancy.

Its light, as is now well known, exhibits properties not possessed by any other artificial light. By it the colors are all readily distinguished, and its actinic or chemical rays are so powerful as to have created an extensive demand for the metal from photographers, who find it desirable to extend their hours of business beyond those of daylight, or to

photograph objects in positions never reached by sunlight—as in the Mammoth Cave.

The attention of the writer was first drawn to this "new light" by a report of Prof. Piazzi Smith, the Scottish Astronomer Royal, regarding its use in the interior of the Pyramids of Egypt nearly two years since, and a further statement before the Royal Society that some apparatus was required for burning the magnesium steadily and economically. The first thought suggested was that it might be made useful as a signal light.

Experiments in this direction have been made in England, but with what success is unknown to the writer.

An experiment, conducted by an able army officer, to ascertain the comparative brilliancy of the magnesium light and the ordinary pyrotechnic signal lights, proved that a ball, weighing fifty pounds, of the latter material, was eclipsed in light-giving power by a ball of only one and a half pounds weight, of similar composition, to which had been added a small quantity of magnesium in fine powder.

Experiment has also shown the magnesium light to be superior to the lime light, and to compete with the electric light in brilliancy, while its cost is less than either.

Early in the present year the writer, then on duty at the Naval Academy, ascertained that Commander S. B. Luce, U. S. N., also on duty at that station, had devised an ingenious application of the Myers system of signals, which was remarkably well adapted to use with an arrangement of colored lights, and was already experimenting, as the writer had proposed to do, with lights of different colors, so arranged as to be exposed or hidden by the withdrawal or intervention of opaque screens.

The light used, however,—the ordinary ship's light,—had so little intensity as to make that system comparatively useless, although at short distances messages could be transmitted with remarkable rapidity.

It was apparent that the use of a light of sufficient intensity would render that system very efficient, and it was determined that experiments should be made with the magnesium light.

The apparatus formerly in use for burning magnesium was, in many respects, objectionable, but a new lamp was designed by the writer, subsequently improved by the American Magnesium Company, and this, the only kind now used in the United States, was used in these experiments.

An experimental apparatus was accordingly designed by the writer, in which one lamp burning magnesium was made to exhibit different colors as required; and with this experiments were, at first, made on shore.

These experiments proving successful, the apparatus was taken to sea with the U. S. Practice Squadron on the last summer, and while at sea Commander Luce made other experiments.

The vessels, between which signals were to be exchanged, were separated as far as possible, without being entirely hidden from each other by the convexity of the ocean, and messages of equal length

were sent each way, first by the magnesium light, then by the usual method of colored fires, and answers were returned.

The experiments proved that the magnesium light could be seen at a distance of eight miles or more with perfect distinctness, notwithstanding the fact that the light was somewhat obscured by the several thicknesses of glass interposed. To send the messages selected, required from six and a half to nine minutes by the magnesium apparatus and system, and about fifteen by the old method, although the latter had been somewhat improved by a device of Commander Luce.

The cost of the message was, by magnesium, *sixty cents;* by the old light, a trifle over six dollars.

Subsequent experiments in Chesapeake Bay were, if possible, still more decisively successful.

The appearance of the magnesium light at sea is that of a brilliant star; that of the usual light a bright flame. The common colored fire exhibits a greater volume of flame, while the magnesium has the advantage in intensity, in rapidity of the transmission of messages—by Commander Luce's system—and in its immensely less cost.

The magnesium may be packed in smaller compasses, and may be used in signaling so long as it lasts, while the lights now used occupy considerable bulk if carried in sufficient quantity for a cruise, give trouble in selecting correct numbers, and if a set corresponding to a single figure be exhausted, the whole stock is rendered useless until a supply of that set is obtained.

The chemical equivalent of magnesium being very low, 12·2, it suggests one reason for the brilliancy of its combustion, and also points to the probability that, by making up the common signal light with magnesium powder, an immense increase of brilliancy, as well as a reduced bulk, may be expected, and thus make them valuable for signaling from the mast-head at extraordinary distances, while the method above described will, from its economy, probably come into use in the naval and merchant services for signaling at moderate distances.

The English and French authorities, it is understood, are experimenting on magnesium with a view to its introduction into light-houses, and the result will be anticipated with much interest by seamen.

Naval Academy, Annapolis, October, 1866.

Cantor Lectures.—On Submarine Telegraphy. By FLEEMING JENKIN, Esq., C.E., F.R.S.

From the London Journal of the Society of Arts, No. 690.

LECTURE II.

(Continued from page 230.)

6. *Statistics of Cables in Shallow Seas.*—The total failures of all kinds, in shallow water, excluding cables which had no proper outer iron protection, did not amount to 100 miles. About 2350 miles have been laid, which worked for some time, but are now abandoned. Of these, 1400 miles weighed less than one ton per mile, a weight which,

for shallow seas, is now known to be absurdly insufficient; these worked for about two years upon an average. 950 miles weighed more than one ton but not more than two tons per mile. The average life of these cables was five years. 5000 miles are now certainly at work; possibly more. They have already worked upon an average of four years and a half. They include one cable which has worked for 15 years, and several 13 years old; but the average is lowered by the long Malta-Alexandria and Persian Gulf cables only lately laid.—Every one of these cables, except the Malta-Alexandria, not originally designed for shallow seas, weigh more than two tons per mile. The interruptions on the lighter cables are somewhat frequent. On the Malta-Alexandria they have averaged four days per 100 miles per annum. Even this is not worse than the best land-lines in India, and is ten times better than the worst land lines in India.

7. *Maintenance and Returns from Cables in Shallow Seas.*—The average cost of maintaining the cables of the Submarine and Electric Telegraph Companies has been for some years from £8 to £9 per mile, excluding the cost of total renewals, which should be provided for by a reserve fund. The expense of the Malta-Alexandria repairs is not known. This line has earned as much as £3000 in one week, or at the rate of £117 per knot per annum. In one year the average earnings during the time it was open were at the rate of more than £90,000, or £68 per knot per annum; allowing for interruptions, the maximum earnings in one year were £64,000, or £48 per knot. The Persian Gulf cable is said to be earning at the rate of more than £100,000 per annum, or £85 per knot per annum. Neither cable has yet worked under favorable conditions; the former ends in a *cul-de-sac*, and the land-lines connected with the latter are so badly worked as to cause extreme delay and uncertainty. Such cables can be laid for sums varying from £300 to £400 per knot. The receipts on the Submarine Company's lines seem lately to have been at the rate of about £85 per knot of cable, or £26 per knot of insulated wire.

8. *Deep-sea Cables.*—Cables laid in less than 1000 fathoms would now hardly be considered as deep-sea cables, but formerly a depth of 300 or 400 fathoms was thought sufficient to entitle a cable to be put in this class, and the old classification has been adhered to in preparing the statistics of shallow sea cables. A cable to be laid in a deep sea must, of course, be strong, both absolutely and relatively, to its weight in water; it must be light, or the great lengths required cannot be conveniently carried; it must not be liable to stretch, and it must coil well and be paid out easily. At first, light specimens of the form already described as used for shallow seas were generally employed. The Red Sea cable is a fair sample. The first Atlantic cable is very similar, but the simple outer wires were replaced by strands of still smaller wires. The examination of Table IV. will show how far these cables met the above requirements. They could support from 4000 fathoms to 5000 fathoms of themselves, hanging vertically from the ship. They could be laid, and about 7000 miles of this class were laid, in depths approaching or exceeding 2000 fathoms, and these

cables have even, for a few miles, been hauled back from these depths. They seldom broke while being laid, but they were not permanently successful. Communication generally ended within a year from the time it was established, and the outer covering was then too much rusted to allow of repairs. The causes of failure were many,—but gutta-percha joints, bad copper joints, injuries to the insulator before the cable was laid, high battery power burning small faults into big ones and eating away the copper lining, from which they were often unprotected. These may be instanced as known causes of failure. It is also said some cables were laid too light, and sprung asunder when the iron wires rusted. It may be conjectured that when these wires rusted the gutta-percha could not bear the cable if suspended across a hollow. These are less probable causes of failure, but it is certain that the rusting of the outside and the failure of the cable generally coincided as to time. The failure was seldom gradual; it was almost, if not always, accompanied by a total fracture or interruption in the copper. When any of these injuries did occur, they were irremediable. The first important modification of the common form was to adopt steel wires instead of iron, reducing their number, and enveloping them in hempen strands, so as to produce a cable which externally looks like a hempen rope. Many excellent experiments were made on this form of cable (which was subsequently chosen for the second Atlantic) by Messrs. Gisborne and Forde, aided by Mr. Siemens. These experiments are given in full in Appendix 10 to the "Report of the Joint Committee on the Construction of Submarine Cables," published by government in 1861. The great strength, both absolute and relative, of this form may be seen from Table IV., showing that these hemp and steel cables will support 11,000 fathoms of themselves hanging vertically in water. The mass of steel required to cover the core is dimisished by the use of hemp, but as hemp is no lighter than water, it does not buoy up the wire. A steel wire simply wrapped up in hemp weighs much the same in water as a bare wire, and therefore wires, whether simply wrapped in hemp or bare, will support equal lengths of themselves in water, but the hemp may be so applied as to add all its strength to that of the steel, although the extensibility of the two materials is different. To do this, the hemp must be spun round the steel with a definite lay, to be ascertained in each case by experiment. Table VI. shows the strength of iron and steel strands wrapped with Russian and Manilla hemp, and with $\frac{3}{4}$ lay and $1\frac{1}{4}$ lay, respectively; also the strength and stretch of the separate materials. It will at once be seen that a difference of lay produces an extraordinary augmentation in the breaking strain and in the elongation. The stretch of a wire when approaching its breaking strain is concentrated nearly at one point, where it rapidly diminishes in diameter. The effect of the hemp is to support the wire at a number of successive weak spots of this kind, and thus greatly to augment the elongation before breaking; but it will further be observed that the breaking strain of the combined materials is actually greater in some cases than the sum of the strengths of the separate materials. Thus the sum of the manilla

TABLE VI.—*Compiled from Appendix 10 to the Report of the Joint Committee on Submarine Cables, (Gisborne, Forde, and Siemens.)*

MATERIALS.	BREAKING STRAIN IN CWTS.			ELONGATION IN PER CENTAGE OF LENGTH.			
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	No. of Experiments.
Steel wire 0·079 in. diameter.....	8·50	8·00	8·20	1·80	1·00	1·41	5
Iron wire 0·079 in. diameter.....	4·50	4·18	4·35	0·72	0·46	·55	7
Steel wire with four strands of { ¾ inch lay	9·25	9·25	9·25	1·77	1·77	1·77	3
manilla hemp .... { 1¼ inch lay	13·00	12·12	12·59	3·12	2·32	2·63	6
Steel wire with four strands of { ¾ inch lay	10·0	9·50	9·70	2·18	1·80	1·76	3
Russian hemp .... { 1¼ inch lay	11·75	10·87	11·42	2·70	2·28	2·45	5
Iron wire with four strands of { ¾ inch lay	4·75	4·50	4·62	0·79	·47	0·63	3
manilla hemp .... { 1¼ inch lay	8·50	8·12	8·28	2·89	2·56	2·62	4
Iron wire with four strands of { ¾ inch lay	5·00	4·75	4·87	0·92	0·66	0·82	3
Russian hemp .... { 1¼ inch lay	7·43	5·00	6·2	2·46	1·04	1·82	6
Manilla hemp weighing 0·05 lbs. to 0·0615 lbs. per fathom	3·87	3·62	3·75	.....	.....	2·62	2
Russian hemp weighing 0·41 lbs. to 0·45 lbs. per fathom	3·50	2·25	2·87	1·40	1·00	1·30	2

and steel, taking the mean strength, is a little less than 12 cwt.; but the mean of the combined strand is more than $12\frac{1}{2}$ cwt. With Russian hemp the sum of the separate strengths is 11·07 cwt., but the combined strand supported 11·42 cwt. The results with iron do not show this anomaly, but the apparant paradox with steel wire has been fully confirmed by independent experiments made for the Atlantic Telegraph Company. The explanation is, that when tested separately we have the strength of the weakest points, or smallest sections of the wires and strands; but these materials are never uniform, and when combined, as it is most improbable that the two weakest points should coincide, we obtain the sum of their mean sections or strengths. The cables formed by these hemp-covered steel wires are very strong. Table IV. shows that the Atlantic cable, relatively and absolutely, is the strongest cable yet made, bearing more than twice as great a length of itself as the old iron cable. The new form stretches more than the old. The hemp may be eaten off, or decay from the wires, weakening the cable, and the hemp affords less mechanical protection against injury; but the stretch is never such as to endanger the core, as has been proved by repeated experiments, and the most serious defect of the cable is probably its expense.

9. *Proposed forms of Deep Sea Cables.*—Rowett's hempen rope could certainly be laid. The lecturer has had no sample of it, but fears it would be extensible. Allan's cable could also be easily laid, so far as its strength is concerned. It is said to coil badly; but the lecturer has not seen this tested. The proximity of the copper and steel inside the cable might cause the steel to rust and burst the core. Still it is desirable that this form should be practically tested. Mr. Siemens' cable, also mentioned in Table IV., will be found described in the appendix to this lecture. The stretched hemp has great strength and elongates little, but has to carry an immense load of copper, which does not add to the strength of the cable. The phosphorized copper sheathing would probably be very permanent. This cable has actually been laid and is now working. A trial of it was not successful in deep water, but a piece was recovered from 1600 fathoms. Duncan's cable, covered with plaited ratan, is too extensible, and the ratan, though durable in water, does not add much tensile strength. The lecturer has had a sample of cable made, in which he used Siemens' stretched hemp, covered with Duncan's plaited cane. Its properties are given in Table IV., and its specification in the appendix. This cable combines great strength, small elongation, lightness, and cheapness. A bare gutta-percha core could be laid easily, but could not be recovered from great depths.

10. *Statistics of Deep-sea Cables.*—Excluding the 1000 miles in abeyance under the Atlantic, and the cable lost in the first experimental trips in the Atlantic, only some 500 or 600 miles of cable have been lost during laying. About 9000 miles have been laid and worked a little while, but are no longer working. From 700 to 850 miles are now at work, but much of this is in no great depth. The Barcelona-Mahon cable, believed still to work, although faulty, is included in

this list. There is but one quite sound cable lying at work in more than 1000 fathoms, viz: that between Sardina and Sicily, 243 miles long. One section of the Malta-Alexandria cable is in 420 fathoms, and has never shown any deterioration. The probable causes of failure have already been enumerated.

11. The general conclusions to be drawn from the statistics given in this lecture seem to be, that in shallow seas, by laying heavy, strong cables, we can insure, and have obtained, success, both from an engineering and commercial point of view; that in deep seas we have hitherto failed, but that success is not unattainable, and may probably be reached by several methods. The lecturer believes that, while in shallow seas, where repairs are possible, cables can hardly be laid too heavy or at too great an expense, in deep seas, where repairs will always be precarious, they can hardly be laid too light or too cheap.

APPENDIX I.—SPECIFICATION OF CABLES IN TABLES.

1. First Atlantic.—Core (*vide* Table III., last *Journal*, page 176) covered with 18 strands of 7 bright best charcoal wires 0·028 in. diameter, called No. 22. Total diameter 0·62 in; weight of iron, 15·64 cwt. per knot.

2. Red Sea.—Core (*vide* Table III.) covered with 18 bright iron wires (? charcoal), called No. 16, B.W.G., diameter, 0·77. Total diameter, 0·56 in.; weight of iron, 16 cwt. per knot.

3. Malta-Alexandria.—Core (*vide* Table III.) covered with 18 bright charcoal iron wires, each 0·12 in. diameter, called No. 11 (?). Whole cable, 0·85 in. diameter; weight of iron, 33·56 per knot.

4. Persian Gulf.—Core (*vide* Table III.) covered with 12 galvanized iron wires, 0·18 in. diameter, called No. 7½ (?); diameter of iron cable, 0·9 in.; covered with hemp and bituminous compound to 1·25 in. diameter; weight per knot of completed cable, 3·7 tons.

5. England-Holland Main Cable.—10 black wires, 0·375 diameter, called No. 00; external diameter, 1·58 inch; weight per knot, 10·4 tons; shore end 15 wires, 0·22, called No. 5, covered with 12 strands made of 3 wires of same diameter, covered with Bright & Clark's composition to 2½ inches in diameter; diameter of iron, 2 inches, and weight per knot, 19·6 tons.

6. Toulon-Algiers.—Core (*vide* Table III.) covered with 10 steel wires, each enveloped in four strands of Russian hemp. Diameter of steel wires, 0·08, called No. 14; diameter of strands about 0·2 in.; weight of hempen strands, (?); diameter of completed cable, 0·8 in.; weight in air, 1·31 tons.

7. Steel and Hemp-coated Gibraltar (proposed).—Core like Malta-Alexandria, covered with 12 steel wires in 4 hemp strands. Diameter of wires, 0·08; weight of steel per knot, 10·55 cwt.; of hemp, 6 cwt.; lay of hempen strands, 1¼ inch; diameter of completed cable, 0·875.

8. Iron and Hemp-coated Gibraltar (experimental).—Like No. 6, with iron instead of steel.

9. Second Atlantic Cable.—Core (*vide* Table III.) covered with 10 bright steel wires, each in 5 manilla hemp strands. Diameter of

each wire, 0·095 in., called No. 13; diameter of strand, about 0·28 in.; weight of hemp strands per knot, about 12·8 cwt.; lay of hemp strands, 3 inches. Webster & Horsfall's homogeneous steel.—Diameter of complete cable, 1·225; weight of steel per knot, about 13·75 cwt., and the serving round core about 2·2 cwt.

10. Siemens' Copper-covered Cable, (sample in Table V.)—Copper conductor, 550 lbs. per knot; insulator, 420; diameter of core, 0·52 in. Stretched hempen strands, 440 lbs. per knot; copper armor, 675 lbs. per knot; diameter of completed cable, 0·75 in.

11. Allan's Cable, (sample in Table V.)—Solid copper conductor, 0·114 in., weighing 240 lbs. per knot; surrounded by 19 steel wires, 0·02 in. diameter, weighing 120 lbs. per knot; diameter of steel strand, 0·16 in.; covered with 300 lbs. of gutta-percha, diameter 0·456, and canvas web; total diameter, 0·522.

12. Ratan and Stretched Hemp, (sample in Table V.)—Core, 363 cwt. per knot; diameter, 0·34 in.; covered with 15 hempen strands, weighing 1·84 cwt. per knot; and covered with plaited ratan cane, weighing 1·84 cwt.; total diameter, 0·625 in.

(To be continued.)

Self-acting Hydraulic Coal-cutting Machine. By W. E. CARRETT, Eng.

Read before the Nottingham meeting of the British Association, Aug., 1866.

From the London Civ. Eng. and Architects' Journal, September, 1864.

In the general detail of mining operations, the cutting away of the under portion of a valuable seam or bed of mineral to facilitate its subsequent removal, is at all times one of the most laborious and difficult operations, and is often effected by the miner under the greatest physical disadvantages; more especially when the seam of coal is very thin, and is cut on the "end" to improve its salable qualities. This "holeing," or "bareing," or "kirving," or "undercutting," is usually performed by about 40 blows per minute from a pick, handled with such experience as to cut 3 to 4 feet under, at the rate of 1 to 1½ yards lineal per hour, and destroying much of the coal to make room for the operator, and enable him to work partly into the hole, to produce the requisite depth for a fall.

The speed and effort with which this picking tool is moved, combined with its weight, represent the power of one man applied in the shape of "percussive force," and this, under advantageous circumstances, is equal to about one-sixth of a horse power. The miner could not, with his limited power, force his pick, or any other shaped tool, into the coal as if he were cutting cheese; he is like the mechanic, who has to chip all his iron work with hammer and chisel, for want of a planing or slotting machine, and must reduce it by little as best he can, "in lieu" of suitable mechanical expedients to concentrate and apply power in a continuous, undeviating, and determined line. Yet the introduction of planing or slotting machines has not injured the mechanic, nor the morticing machine the joiner. There is ample work which the machine cannot do, and there are innumerable mines where

no machinery can compete with the skilled miner. To apply the power of horses in lieu of manumotive power, even though one horse is as powerful as six men, is practically very difficult. The power of both is dependent on the produce of cultivated lands; and the fewer horses required the cheaper the necessaries for human sustenance.

There is yet a far more effective substitute for the power of both man and horse, which has been inviting our use for centuries, in the form of what George Stephenson conceived to be "bottled up sunshine." A coal-fed steam engine of one horse power is twelve times cheaper than one animal horse power, and our obedient servant for twenty-four hours daily, consuming the produce of uncultivated lands on which the sun shone ages ago.

Now, it is desirable that in many favorable circumstances this "undercutting operation of the miner should be accomplished indirectly by this steam power, and one of the practical methods of accomplishing this object is the subject of the present consideration.

If one collier had the power of say 18 men, and, when necessary, could make himself 2 feet high, and hold himself down upon the floor of the mine by pressing his head against the roof, and hold firm in his hands a kind of cheese scoop, in lieu of a pick, and could force it steadily into the coal at the necessary height from the floor, and to the required depth, he would then be exactly what is in many cases wanted. He would be a traveling morticing machine, and do more in one minute than 700 blows from a hand-wrought pick can do, and would, in fairness, demand a very stiff wage, which he would undoubtedly obtain.

This is what the iron man or hydraulic coal-cutter accomplishes. "He" is, if necessary, 2 feet high, has four legs, of adjustible length; his head is also adjustable to touch the roof, and he weighs one ton. He is fed by a 2-inch flexible pipe, with sober drink, at 300 lbs. pressure, and at the rate of 30 gallons per minute.

This water pressure acts vertically on a 5-inch piston pressing against the roof, and horizontally on one about the same size, reciprocating 18 inches, and 15 to 20 times in a minute. There is a pressure of 5000 lbs. against roof, and the same pressure acting horizontally, forcing 3 "cheese scoops" into the coal. These cutting tools are 3 inches wide, and penetrate 4 feet, with a power equal to 3 horses or 18 men; and this is effected by a consumption of 50 lbs. of coal per hour to feed the boiler of the engine, which makes the water pressure, and pumps the same over and over again. Thus this automaton iron man is dead-fast when forcing the cutters into the coal, and only requires to lower his head 1 inch at the return or back stroke, and advance, which he does also self-acting, at its termination, ½ an inch to 1 inch, and then again he elevates his head and is ready for the next cutting stroke; his sober veins being filled by incompressible if not exhilirating "water," and retained therein by a keep-valve for the necessary time, enabling him at that moment to defy the roof to crush him. This self-acting hydraulic coal-cutting machine, or "iron man," which has now been two years at work, is the miners' best friend.

It does not dispense with his labor, but performs for him the undercutting, a most laborious operation, either in the end or face of coal, and in a more efficient and economic manner than he can do it himself. The coal so operated upon by the machine does not fall forward when becoming detached from the roof, but settles on the lower bed, thereby avoiding serious accidents. The saving in coal alone more than pays for the outlay; and it is practicable to cut with the most perfect ease into the floor of the mine, thus preventing all waste of coal whatever. The size of the coal is improved, the amount of slack is considerably reduced, and a single seam will yield more by one thousand tons of coal per acre, than when worked by hand labor in the usual manner.

The machine undercuts "holes," or "kirves," with a man and boy as attendants, and completes the work with once going over, at the rate of fifteen yards per hour, and at any angle and height from floor or rails, being suitable for either "dip" or "rise" workings, and is capable of cutting the thinnest seams. The pressure of water which actuates this apparatus can be obtained either from the stand-pipes in the pit, or from pumps attached to any existing engine, or from an engine and pumps specially made for the purpose. The quantity necessary is only what is sufficient to fill the circuit of the pipes, using it over again when desirable, as in the Bramah press. Any idea of a large volume of water being necessary may therefore at once be dispelled. There is also no leakage whatever.

Each machine uses thirty gallons per minute, at about 300 lbs. pressure, according to the hardness of the coal or mineral to be operated upon. In cutting the shale of the Cleveland ironstone band, a somewhat greater pressure is found to be necessary. There is no limit to the pressure of water that may be used, nor the distance it may be forced without loss of power, beyond that due to its friction along the pipes. The same water pressure is also applicable to work pumps and rotative engines for hauling, &c., and other requirements in the mine, at a distance from the engine power. In cases where there is a fall of water, say of 100 lbs. pressure, it can be "intensified" by a self-acting machine to 400 lbs. pressure, to work the coal-cutter, but sacrificing three-fourths of the bulk, which is thereby set free.

The water is supplied in a continuous stream; it is, in fact, the medium through which the mechanical power is applied direct from the first coal-fed motor, (a steam engine and pumps,) in lieu of the usually developed power derived from vital energy, and applied to the handle of a pick, effecting the desired object by a series of percussive blows or impacts. The power of six men is equal to one horse, and is six times more costly; and the power of one horse steam motor, or engine, is eighty times cheaper than six men. The machine is about three horse power, and weighs one ton, and will work either right or left. It is self-acting in all movements, and will ascend the steepest gradients. Being simple in all its parts, it is not liable to get out of order, and is easily managed by an ordinary miner, and transported from place to place, on the ordinary rails, about the mine.

Although the length of stroke of each cutting tool is eighteen inches, the practical cutting length is sixteen inches, and, consequently, the three cutters jointly give a total effective depth of four feet at each stroke of the machine, finishing the work as it goes along. The mechanism employed consists of an hydraulic reciprocating engine, adjustable to any height and angle, having a self-acting valve motion. The cylinder is four and a half inches diameter, and lined with brass, and the piston made tight with ordinary hydraulic leathers, easily renewable. Within the piston-rod is attached the cutter-bar of steel, carrying the tools or cutters. These can be varied in number to suit the depth to be holed at one operation. The cutting tools are of double sheer steel, easily made, and very strong, and can be removed and replaced in a few moments; they are readily sharpened on an ordinary grindstone. The cutter-bar is also removable, when transporting the machine from place to place, for which purpose the main cylinder is, for the time being, placed longitudinal with the rails.

The machine in operation fixes itself dead-fast upon the rails during the cutting stroke, and releases itself at the back or return stroke, and traverses forwards the requisite amount for the next cut, without any manual labor. Should the tools be prevented making the full stroke at one cut, they will continue to make more strokes at the same place, until the maximum depth is attained, when "only" the machine will traverse itself forward the required amount for the next cut. Thus, at one operation, a uniform straight depth is attained, parallel with the rails, inducing an even fracture when the coals are brought down, and thereby a straight line for the new coal face. There is no percussive action, either against the roof or into the coal, but simply a concentrated pressure, producing a steady reciprocating motion, at fifteen strokes per minute. There is, consequently, no dust or noise, and little wear and tear. For the same reason, when cutting pyrites, the tools throw out no sparks, and the workman can hear any movement in the coal or roof.

The required height from the line of rails in the "holeing," "kirving," or "bareing" varies in different mines. It follows that the hydraulic cutting cylinder, and its direct action cutting tools, have sometimes to be arranged above the carriage, and sometimes beneath the main carriage, or close down upon the rails.

Traction Engines.

From the London Journal of the Society of Arts, No. 721.

A train drawn by a locomotive on the common roads has recently arrived at Paris. The following details will be read with interest: The locomotive has a tubular boiler, carries a tender, a water-tank, and footplate in front of the engine. The engine is on the top of the boiler; it has two cylinders, with reversing gear. It is worked from the front by means of a guide-wheel, which is moved by one man; it works with ease and perfect regularity; it can turn in curves of a very small radius, and can follow all the windings of the road. This engine, travel-

ing on a level road, or on one that presents no gradients of more than three per cent., draws an actual load, after deducting the weight of the wagons, of 12,000 to 15,000 kilos., or from twelve to fifteen tons, at a speed of four to six kilometers, or from 2½ miles to 3¾ miles per hour. It draws at high speed, that is to say, 14 to 16 kilometers per hour, or nine to ten miles, a clear weight of 1000 to 4500 kilograms, or from one to four tons and a half. The wagons are coupled one to another as well as to the locomotive, and by a mode of coupling which allows them to follow all the movements of the engine, however much it may deviate from the straight line. The engine stopped at a great number of places on its journey from Nantes to Paris, in order to satisfy the public curiosity.

The Festiniog Railway.

The following discussion was elicited in the Institution of Civil Engineers, of Great Britain, by the reading of an article by Capt. Tyler, R.E., on the Festiniog Railway, which may be found in the *Civil Engineer and Architect's Journal.* The article itself does not present any especial interest to us, and we omit it; but the discussion is so full of facts which will interest and may benefit our engineers, that we republish it for their benefit:

Captain Tyler said: Having been called upon officially to inspect this railway, he thought a brief description of it might be interesting, and he hoped that description would be the means of calling forth a discussion of great use, in elucidating the important question, whether it was desirable to have a narrower gauge in this country, under peculiar circumstances of locality, and having regard to the nature of the traffic. There were already in Wales a number of different gauges used on tramways for bringing slates and minerals down to the ports of shipment, and in other countries different gauges were springing up. In Queensland, he had been informed, one hundred miles were in course of construction on the gauge of 3 feet 6 inches, and two hundred miles more were projected on the same gauge. It was important to ascertain, what would be a suitable gauge in those instances where the traffic was not likely to be large. Farmers were now using portable railways for transporting the produce of their fields, for bringing their harvests, spreading manure, &c., and there seemed no reason why districts, which could not support a railway on the gauge of 4 feet 8½ inches should be altogether deprived of the advantages of railway communication. The question of gauge was, in one sense, a question of speed. Speaking roughly, on a railway of 2 feet gauge, with 2 feet driving-wheels, traveling might be made as safe at twenty miles per hour as on the Great Western, with its 7 feet gauge and 7 feet driving-wheels, at seventy miles per hour. He had traveled on parts of this little line at the rate of thirty miles per hour with every feeling of safety. He regretted the unavoidable absence of Mr. Spooner, because it prevented him thanking that gentleman, in the presence of the meeting, for the information afforded during the preparation of this paper, and because, if

he had been present, he would have been able to give further information on the subject. Mr. Spooner took great interest in this line, and was accustomed to travel on it along the Traeth Mawr embankment in a boat carriage, not inappropriately named "Ni l'un ni l'autre," being carried along by a sail. The preliminary expense in first applying locomotive engines, and making numerous adaptations on so narrow a gauge, were considerable; but since the line had been in working order, the following results were shown:

Statement of the comparative cost of working the Festiniog Railway by horses and by locomotive power.

BY HORSES.

	£	*s.*	*d.*
Contract for the carriage of slates and minerals, 70,000 tons at 8*d.*, the contractor finding labor, grease, and oil	2333	0	0
Contract per ton on 9000 tons of coals, train, and other merchandise, ditto, at 3*s.*, the draft being ditto, less journey	1350	0	0
No passengers, and no cost for porterage			
	£3683	0	0

BY LOCOMOTIVES.

	£	*s.*	*d.*
Locomotive department (wages)	740	0	0
Materials for repairs of locomotive tender and van	200	0	0
Fuel, oil, and grease required for working traffic, including oil for signal lamps, &c	636	0	0
Additional expenses and wages, keeping train in repair, over above amount by horse power	296	0	0
Additional cost in keeping up permanent way	680	0	0
Additional attendance in signal men on the horse system	334	0	0
Cost of working train by locomotive	2886	0	0
Cost of working train by horses	3683	0	0
Difference in favor working by locomotive nearly 22 per cent...	£797	0	0

Mr. G. W. Hemans said he had seen this railway, when worked by horse power, about three years ago, and was glad to hear now that it confirmed the impression he then entertained, that the project of working it by locomotive power would be successful. The idea of using locomotives arose from the competition branch line, which was contemplated by the owners of the ordinary gauge lines, leading along the Welsh coast, and which branch was to penetrate into the slate district. He was called upon to examine as to the propriety of this branch line on the ordinary gauge, for the purposes of the slate quarry, and the result of his observation was, that for those purposes that gauge was unsuitable, and that no better thing could be devised than the existing 2 feet gauge. The small wagons on this gauge were carried over steep inclinations of 1 in 12 and 1 in 15, and in some places of as much as 1 in 5, or in 6, so as to penetrate into every part of the immense slate quarries of Festiniog. The slates brought down on these extensive ramifications were expected, if the ordinary gauge branch were constructed, to be delivered at the foot of the inclines, to be there gathered together, and the narrow wagons would be hoisted into broad gauge wagons and taken to the port. This would clearly have proved

a great inconvenience, and the project of using locomotives on the 2 feet gauge, as far as the foot of the steep inclines, seemed so feasible that he gave it his warm support, and the consequence of the opposition to the broad gauge branch was that it was withdrawn, and the project of working the narrow gauge by locomotives was carried out. He thought the attainment of a fair speed by the narrow gauge locomotive was, to a great extent, as safe as on the broad gauge, provided the wheel base was properly proportioned to the engine. With regard to the economy of the working, another question arose. As to the general principle, whether it was desirable to encourage very narrow gauge lines in positions of this kind, it depended upon the nature of the traffic. He doubted whether that system could be extensively used for passengers; but where there was a large amount of mineral traffic coming out of narrow galleries, all going in one direction, and but a small passenger traffic, going in either direction, he had no doubt a system of narrow gauge railways might be advantageously adopted. He thought it a matter worthy of legislative inquiry, whether this system might not be beneficially extended upon some well-considered gauge. At the same time, as a general principle, there was great objection to alteration of gauge. As regarded Ireland, the adoption of the gauge of 5 feet 3 inches had not produced beneficial results.

Sir Charles Fox remarked that he had had a great deal to do with railways of various gauges. It was a subject to which he had given more attention than perhaps any other. He thought break of gauge was a serious matter, and yet it was difficult to say there never should be break of gauge. As joint engineer of the Indian tramway, with regard to which line a question arose as to what gauge should be adopted, he wrote a long report, in which he advised that that company's lines should not be made tramways, but light railways; and as in almost all cases such lines would be tributary to main lines, the gauge of which he believed was 5 feet 6 inches, he advised that the tributary branches should be laid to the same gauge; but he coupled that advice with what he thought was an important condition, which was, that the load upon each pair of driving-wheels of the engine to run on such lines should be limited to the greatest load that could by possibility come upon any pair of wheels in a train. He calculated 6 tons on each pair of wheels, and he did so for this reason: he considered that the tributary lines in India, if intended to pay, ought to be worked by the rolling stock of the parent lines. All the rolling stock of the parent lines, except the locomotives, might with safety be carried on rails of not more than 35 lbs. to the yard; but there must be locomotives of not more than about 18 tons on three pairs of wheels, or if of 24 tons, on four pairs of wheels, thus equalizing the total load by placing 6 tons on each pair of wheels. But whether the gauge was 3 feet 6 inches, 4 feet 6 inches, or 5 feet 6 inches, the rolling stock need not be comparatively heavier in proportion to the greater width of the gauge; and if the weight were restricted to 6 tons on each pair of wheels, the light permanent way would be able to do the work. The report to which he alluded, after being considered by the direct-

ors, was not acted upon. The line between the Arconum and Conjeveram, forming a junction with the Madras main line, was of the gauge of 3 feet 6 inches; but since then the governments of the three presidencies came to the determination that no tributaries to main lines should in future be of any other gauge than 5 feet 6 inches, the only condition on which a narrower gauge was to be permitted being where the line was not tributary to a main line, and even that, he believed, was not yet fully determined upon. His own opinion was, that the government would adhere, in all cases, to the resolution requiring the gauge of 5 feet 6 inches. On the other hand, the objection to a uniform gauge for both main line and tributary branch was, as alleged by the managers of the companies, that they had no proper control over their servants, and that if a man was accustomed to drive an engine of 30 tons on the main line, he could, if he chose, run the same engine on to the lighter road, very much to its injury; whereas, having a different gauge effectually prevented this being done. He thought that there should be no separate establishment for the repair of those engines, but that all the locomotives should be the property of the parent company. The engines could then go to the same shops to be repaired, which would be a convenient and economical arrangement, particularly on a short branch. On the line to which he had referred, he had been obliged to send out all the tools necessary for the repair of the engines of 3 feet 6 inches gauge, whereas if the gauge of 5 feet 6 inches had been adopted, arrangements might have been made for the whole of the rolling stock to be repaired by the parent company, under an agreement with the branch undertaking. He thought it was more important to limit the weight on the driving-wheels than to fix any particular gauge, the latter being a matter which must be determined by the circumstances of each case. After a good deal of consideration on the subject, he thought if he had now to establish a gauge to be used all over the world, he should fix it at 5 feet 4 inches. The Irish gauge of 5 feet 3 inches was a very good gauge. The Indian gauge of 5 feet 6 inches was also a good gauge, but it necessitated a rather heavy rolling stock, while the gauge of 4 feet 8½ inches was in his opinion too narrow. At the same time, unless there was some strong reason for departing from the universal gauge of any country, he would follow out that gauge in even the light tributary lines.

With respect to Queensland, the government of that colony had decided beforehand upon making its lines on the gauge of 3 feet 6 inches, and the plans were referred to him for confirmation. More than 100 miles were now being constructed, and authority had been obtained for 200 miles or more, the "matériel" of which was now being prepared. In the case of the Indian branch of 3 feet 6 inches gauge, all the "matériel" and rolling stock had been sent out from England, the sleepers being of teak. The line was laid upon an old road, which was granted to the company by the government, and which required some alterations in its curves and gradients. The total cost, including rolling stock, would be not quite £3500 a mile.

With regard to the radiating axle-boxes referred to in the paper, and which had been adopted for sharp curves on the Norwegian lines, he was so satisfied with them that he was sending such boxes out to Queensland. He believed that, on the Queensland railway, 5 chains was the sharpest curve, and that 1 in 40 was the steepest inclination; that the weight of the rails was 40 lbs. to the yard, and that the engines with six wheels did not exceed 15 tons in steam, ready for work, exclusive of their tenders, carrying fuel and water.

The most important reason for using the narrow gauge, in this instance, was for the construction of circuitous lines through mountain ranges, where it was impossible, except at very great cost, to have curves of long radius. If it had not been for the sharp curves, he would not have recommended the narrow gauge for the Queensland lines; and it must be borne in mind that these, being the first railways in that colony, there was no existing gauge to which the gauge of these lines had to be adapted. He hoped, however, that his remarks did not lead to the supposition that he would lay down a railway, with a gauge 5 feet 6 inches, to a slate quarry in Wales. His observations applied only to such lines as were tributary to main systems of railways.

Mr. Peter Bruff remarked that all the Norwegian lines alluded to were isolated. The original line made by Mr. Stephenson and Mr. Bidder had been extended to the confines of Sweden, and was entirely constructed on the gauge of 4 feet 8½ inches, with which the other lines of the country were never likely to be brought into communication. Radiating axle-boxes, he understood, had been recently introduced on the Norwegian lines with considerable success. The weight of rails generally adopted was 37 lbs. to the yard, laid in lengths of 21 feet, the rails being flat-bottomed, 3½ inches high, with a base of 3 inches, laid on cross sleepers, and fish-jointed. In some cases, a plated joint had been used, which, from the experience obtained in England, was not considered a desirable arrangement. Upon the subject of narrow gauge Norwegian railways, he had, however, received a communication from Mr. Pihl, who, in 1856, was entrusted by the Norwegian government with the task of supplying railway communication between Throndhjein (about 350 miles northward of Christiana) and Storen, the point from which two main carriage roads ran south, and between Hamar, on the Lake Mjosen, about 56 English miles north of Christiana, (with which it was in direct communication by rail and steamer,) proceeding eastward to Eleverum, upon which the traffic of the Glommen valley converged. Mr. Pihl stated that he determined, from the difficulties of the country and the smallness of the traffic to be accommodated, that he should not be justified in recommending such an outlay as would be involved by the formation of a railway as ordinarily constructed. He therefore recommended a gauge of 3 feet 6 inches. This was adopted by the government, and confirmed by the legislature (Storthing) in 1857, and shortly afterwards the works of both lines were proceeded with.

The works upon the Hamar line, being the more easy of construction,

were sufficiently advanced to be used for goods traffic in the summer of 1861. The total cost of this line, for 24½ English miles, had amounted to about £3000 per English mile. This included a large iron bridge, on stone piers, about 900 feet long, for ordinary road purposes only. The rolling stock of three locomotives, six passenger carriages, three break vans, and fifty goods wagons, with the necessary ballast wagons and tools for repairs; also two terminal stations, and six intermediate stations and stopping places, a carriage shed, and a small repairing shop. Although the works were not of a heavy character, there were, nevertheless, many difficulties to contend with, the lines having to ascend upwards of 400 feet, and to cross extensive and deep swamps.

The Throndhjein line of 31½ English miles, running through a difficult country, required many heavy works of construction, among which were numerous large bridges, some being from 70 feet to 100 feet high, several cuttings containing from 50,000 cubic yards to 70,000 cubic yards each, and others through rock of more than 30 feet in depth. The cost of this line was necessarily greater than the former, in all about £5000 per English mile, including four engines, eight passenger carriages, three break vans, sixty goods and plank wagons, besides twenty ballast trucks, with the necessary implements for the repairs. There were besides the terminal stations, six intermediate stations and three stopping platforms. At Throndhjein there were also goods and carriage sheds, and a workshop for the repair of the rolling stock. This line had to cross a ridge more than 500 feet in height, in the first Norwegian mile from Throndhjein. The greater part of this distance was constructed on one side of the ridge with gradients of 1 in 42 and 1 in 65, and on the other side of 1 in 52, the curvature being of about 900 feet radius; whereas, on the other portion of the line, where the gradients were seldom more than 1 in 100, curves of 750 feet were frequently resorted to. The width at the formation level in cuttings and on embankments was 13 feet nearly. The slopes, according to circumstances, were from 1½ to 1 to 3 to 1. The ballast was 8 feet wide at the top, and 1 foot 9 inches in thickness. The sleepers were of half-round pine, 6 feet 6 inches long, placed 2 feet 6 inches apart on the curves and steep gradients, and 2 feet 9 inches apart on the straighter portions of the line. The rails were flat-bottomed and fished at the joints in the usual way, 3¼ inches in height, and weighing 37 lbs. per yard, except on the steep inclines, where rails of 41 lbs. per yard were laid. The rails were fastened to the sleepers by dog-spikes only, no bolts or bottom plates being used. Ransome's chilled crossings, and Wild's self-acting switches were used throughout. The bridges were all of timber, except where large rivers had to be crossed, and spans of from 50 feet to 100 feet were required, in which case stone piers were carried up above flood-level. The superstructure made use of in those cases was Howe's system of trellis work, with iron suspending rods. The rolling stock consisted of tank engines with three pairs of wheels, two pairs being coupled for drivers, these having an available weight for traction of from 11 tons to 15 tons, out of the 14 tons to 15 tons, the total weight. The last engines procured were provided with

bogies on Bissel's or Adams' system. The cylinders were 10 inches in diameter, with a length of stroke of 18 inches, and the driving wheels were 3 feet in diameter. All the engines were made in England, with the exception of one made at Throndhjein, and were working efficiently. The passenger carriages were constructed to carry the usual number of passengers, as in England, and were arranged for two classes only, the compartments being fitted up as first and third. The goods wagons were made to carry 5 tons, and were only a few inches narrower than the ordinary kind, these widths being obtained by having the springs attached to brackets inside the sole bars, thereby allowing the lowering of the body and, in consequence, the centre of gravity. The buffers were all central, and 2 feet 6 inches above the rail-level, and served also as draw-bars. The couplings on those last constructed were self-acting when the wagons were brought together. As this narrow gauge allowed a correspondingly larger wheel-base than the ordinary gauge, the wagons ran very steadily. Some of the wagons were constructed to carry planks 24½ feet long, and had a length of wheel-base of 13 feet.

The usual rate of speed was about 15 miles per hour, including stoppages, and the trains ran quite as steadily on this line as on the broader gauges. The traffic on these lines, though considerably below that of the lowest of the English lines, had already fully paid the working expenses, while the impulse given to the development of the resources of the country must undoubtedly, in course of time, produce a corresponding and satisfactory increase of revenue.

In order to show the economy of construction, Mr. Pihl mentioned that, simultaneously with the construction of these lines, an extension of about 50 English miles were constructed, from the old trunk line built by Messrs. Stephenson and Bidder in 1850–53 to the Swedish frontier, of the ordinary gauge of 4 feet 8½ inches, the cost of which was about £6400 per English mile, the rate of wages and the class of work being, as nearly as possible, of the same description.

In addition to the two narrow gauge lines described, there was in course of construction another line of the same gauge, between the town of Drammer and the Lake Randsfjorden, about 57 English miles in length, besides several branch lines in preparation. None of these several lines would ever have been made had not the small cost justified and encouraged the undertakings.

Mr. Pihl added that, last summer, Mr. Charles D. Fox inspected the narrow gauge lines in Norway. All the details, with the engines and rolling stock, were unreservedly placed at his disposal; and on leaving he wrote: "With reference to the interesting question of the 3 feet 6 inch gauge, I shall return convinced of the thorough efficiency of such a gauge for the purpose of a new country, and of the wisdom of adopting such a gauge where the traffic is not very heavy."

Mr. Phipps inquired, whether the economy of these narrow gauge lines did not consist chiefly in the diminished cost of construction, rather than in working the traffic of the line? In his opinion, the cost of haulage per ton could not differ much, whatever the gauge might be; but as regarded the construction of the line, it would, of course,

be less for the narrow way. These narrow ways were obviously suited for mountainous districts, where, the curves being necessarily sharp and frequent, it became important to reduce, as much as possible, the friction arising from wheels keyed fast upon the axles, which was obviously done by diminishing the width of gauge. On tolerably level ground, with the ordinary alternations of cutting and embankment, where the slopes formed so large a proportion of the whole earthwork, the saving from narrowing the gauge would probably not be considerable.

Mr. Bruff replied that, though considerable economy in the earthworks arose by adopting sharp and reverse curves on the Norwegian lines, the bridges and viaducts were extremely heavy, so much so as to have astonished him when he was informed of the prices at which the lines had been carried out. No doubt, the economy of construction was greater than if a heavier rolling stock and permanent way had been employed throughout.

Mr. Gregory, V.P., remarked that, with the narrow gauge, a shorter wheel-base of the engines could be adopted, which gave greater ease in traversing sharp curves.

Mr. Robert Mallet said, as yet no mention had been made of another narrow gauge line, which had been a long time in successful operation, viz: that between Antwerp and Ghent, the gauge of which, he believed was only 2 feet 3 inches. He could not give the precise particulars of the rolling stock, but could state, generally, that the carriages were wider than those on the Festiniog Railway, and they carried heavier loads.

The subject of narrow gauge lines was not new to him. About eleven years ago he recognised the advantages in respect of cheap railways and traffic, which would arise from narrow gauge lines; and in 1855 he had proposed to Mr. Hemans a line along the north shore of the Bay of Dublin to have a gauge of only 2 feet 6 inches. That project, for reasons it was not necessary then to go into, was not carried out. A bill, however, was presented in the present session of Parliament for a similar line, and he hoped it might be made on the narrow gauge. In viewing the question of narrow gauge and ordinary gauge railways, it was necessary to consider what he might call the prudential considerations, those that related to the circumstances of traffic, &c., separately from those which were of a purely physical character. He met in Sicily last year Colonel Yule, late of the Bengal engineers, and he had had many opportunities of discussing with him what had passed relative to Indian tramways, or ranch railways. Colonel Yule's opinion was decidedly in favor of narrow gauges, and he considered that in India it was simply a question between the bullock-cart, or these narrow gauge lines, as feeders to the trunk lines. Reverting now to the purely physical considerations, it appeared to him, as a physical necessity, that, not only the original cost of two similar lines differing in gauge, but also the cost of working them, would approach the ratio of the cube of the length of axle, or, what was the same, of the breadth of gauge. A little consideration would show that, however startling, this proposition, without having any pretensions to be a mathematical truth, was never-

theless, approximately true. As an illustration of this, if the axle of a carriage, as a cylindrical shaft, exposed to cross-strains, were taken, it would not admit of dispute, that for equal strength, on different gauges, the diameter must vary as the cube of the length, or of the gauge. Therefore the weight of the axles would be in the ratio, and so must be that of the wheels to carry them. Then as to the carriages: as it was equally undeniable that the weights of any similar structures whatever, varied as the cubes of their homologous dimensions, so the weight of the carriages would be as the cubes of the gauge, if the carriages were of equal lateral strength: and the axles and wheels must be proportionate to carry this load. In a word, all the rolling stock would be increased in something like the ratio of the cube of the gauge. If this were so, it followed that the permanent way itself must be increased in a proportionate ratio to bear that load; and if it were true, that the cost of haulage was a function of the weight drawn, it equally followed that the rolling expenses, or those for working the line of road, would be about in proportion to this increased weight of rolling stock also. He wished to guard against being mistaken as now speaking mathematically, or as using the cube as a precise expression of the relation. His intention was merely to illustrate the proposition, which he deemed generally true, that not only the first cost of construction, but also the expense of working railways, increased with the width of the gauge, but in a greatly higher ratio, or, in other words, that in proportion as the gauge was reduced, both the first cost and the working expenses would be diminished. There were some special physical advantages in narrowing the gauge; for example, engines or carriages could go round a sharp curve more easily with a 2-feet gauge than with a 7-feet gauge. This fact had had some doubt thrown on it, but its truth was obvious, from the consideration that, if the two rails could be brought close together, or into one, there would be no longer any resistance at all in going round, due to the outer and inner wheels having to go over different lengths of curve in equal times.

Mr. Savin said, he had not at first imagined that a line of so narrow a gauge as the Festiniog Railway could be worked successfully with locomotives; but he had traveled on that line both with locomotives and in the boat carriage, and he thought it a great success, both in regard to its adaption to the circumstances of the locality and in its commercial results. He agreed that the gauge of railways in any one country should be uniform, as far as through systems of working were concerned; but, having had some experience in Wales, he thought it impracticable to carry out the broad gauge in that country. He had seen various gauges in operation, from 2 feet up to 3 feet 6 inches. His own feeling was in favor of 2 feet 3 inches or 2 feet 6 inches, where the valleys were crooked and steep-sided. In this way many physical difficulties might be avoided, by the adoption of curves of shorter radius; a 2-feet gauge line might be fitted to the contours of the hill-sides, in such a manner as to reduce the cost of railway communication to a minimum. A line 16 miles long, for which he had given £20,000, was laid on the gauge of 2 feet 3 inches, and that line

had been extended into a district similar to that which the Festiniog Railway passed through. There would have been very little chance of carrying a bill for a railway on a gauge of 4 feet 8½ inches in that district, and the result would have been, that, but for this class of railway, the present development of the mineral resources of those valleys would not have been attained; and it was especially with reference to districts such as this, that the subject was worthy of the fullest consideration on the part of engineers.

(To be continued.)

Unsinkable Vessels. By JAS. PARKER.

From the London Mechanics' Magazine, April, 1866.

As the late catastrophe has called public attention to the dangers of ocean traveling, will you allow me space to explain a plan, which, if adopted, would render every kind of vessel perfectly safe from foundering? When any part of a vessel gives way and admits the water, the usual remedy is to pump it out as quickly as possible, either by manual power, or, in case of steamers, by steam power, and great importance is often attached to the power of steam pumps, which, however, are often found useless in the hour of danger. Supposing a serious leak to have occurred, then follows the fight of the crew and passengers for life against the enemy. At one time the crew may gain a little, and at another the water gains a slight advantage; and unhappily this miserable and exhausting battle is not by any means an uncommon occurrence. It seems to me that the whole system of endeavoring to keep down the water by any kind of pump is radically wrong in principle, for by pumping out the water space is left for more to come in. The true remedy is to pump air into the vessel, whereby each gallon forced in becomes a clear gain to the stability of the vessel, and leaves so much less space for water to occupy. A very little exertion in this way would soon render a vessel of 1000 tons perfectly safe from foundering, without reference to the size of the leak, which might increase sufficiently to let the engines and boilers fall through the bottom of the vessel, without in the slightest degree adding to the danger of the vessel's sinking.

I therefore propose that all passenger vessels should be compelled to carry such a number of air-tight flexible bags as, when inflated in the different parts of the ship under the decks, would by their bulk prevent the vessel from sinking, even if the water had free access. The expense would not be a very large item, and nothing in comparison with the value of the sense of security to the passengers, and, therefore, of higher passage money. An iron vessel without compartments, laden with stone or iron, if protected in this manner, would be just as safe from sinking by having a hole knocked into her bottom as a timber laden ship. The bags, of say from twenty to fifty or more gallons, could be kept permanently filled with air in all vacant spaces of the

ship not required to be visited during the voyage, and, upon the appearance of danger, other bags could be inflated in proper positions in the cabins or elsewhere, until the bulk occupied was more than sufficient to support the ship. A bump on the rocks, leaving a large hole in the ship's bottom, provided the vessel did not break up her decks, would not then be of any great moment. In the case of steamers the bags could be filled by air forced by the steam in a few minutes.

In some experiments lately tried on the Thames in propelling a large boat with air, without machinery, I forced into the water, by aid of the steam from a one horse power boiler, about 1000 gallons of air a minute, and obtained a speed of three miles an hour through the water. If the *London* had been properly fitted upon the above plan, the steam from the boiler of her donkey engine would have rendered her perfectly safe from foundering in a few minutes.

MECHANICS, PHYSICS, AND CHEMISTRY.

On the Supposed Nature of Air prior to the Discovery of Oxygen.

By George F. Rodwell, F.C.S.

(Continued from vol. 1., page 346).

From the London Chemical News, No. 316.

XIV. *Rise of Pneumatic Chemistry.*—We can scarcely be surprised that the air received but little attention till a comparatively late period in the history of the world, when we remember that there existed no means of ascertaining even its most salient properties. Inquiries into the nature of an intangible and invisible body, which exercises no apparent effect upon the matter around it, belong to a somewhat advanced stage of experimental philosophy. They require the assistance of a large amount of collateral knowledge, of a refined manipulation, of a mind tutored in the mode of physical thought, and used to the classification of diverse phenomena. The most obvious property of matter is its visibility, and the conception of it divested of that property is no small effort to an ordinary mind. We all know the invariable wonderment produced at a popular lecture when carbonic acid is poured upon a lighted taper, or when hydrochloric acid gas and ammoniacal gas are brought into contact. When we call to mind the ideas which obtain among the unscientific in the present day in regard to gaseous bodies, we cannot wonder that so little was formerly known of the air.

The ancients, although they classed air among the four elements from which they conceived the world had been produced, had no definite idea of its nature. Many philosophers doubted whether it were material, and the great mass of the people scarcely recognised its existence. The fact adduced to prove its materiality (the simplest and most obvious that could occur to the mind) was that it could be felt when in motion, viz: as wind. Anaxagoras went a step further, and urged as an additional proof (*a*) that a blown bladder resists com-

pression, and (*b*) that an inverted drinking vessel, when plunged beneath the surface of water, is found to remain perfectly dry inside, which would not be the case, he argues, unless something material had prevented the ingress of the water. But these crude experiments merely proved that the air is matter.

Then, again, the experiment of burning a candle in a closed vessel standing over water, could throw no light on the nature of the air, as it could not be rightly explained in the then state of science. It may be considered the earliest experiment in pneumatic chemistry; it is mentioned by almost every Middle Age writer on alchemy and chemistry, but scarcely two give a similar explanation of the phenomena observed. Nor is this to be wondered at, when we remember the amount of chemical knowledge required for its explanation. To explain it in its entirety it was necessary to know (*a*) that the air is composed of two gases; (*b*) that they are insoluble in water; (*c*) that during combustion one of them unites with the burning body; (*d*) that a gas soluble in water is the result; (*e*) that the other gas cannot unite with the burning body; and (*f*) that in a known volume of air there are four volumes of the latter gas to one of the former. No wonder the experiment puzzled the scientific mind for so many centuries. No wonder it became a habit to fasten a pet theory upon it, or to propound one specially for its explanation. Those old philosophers, who with difficulty spun out a page or two about it, little thought how much was linked with the true explanation of the experiment, how their ponderous and unwieldly theories, upon which so much thought had been expended, so little experiment, would have disappeared utterly; how the face of science would be changed when a new race of thinkers, working slowly and laboriously, were destined to elucidate each phase of the experiment.

But although this experiment remained unexplained, it proved to the more observant the important fact that flame requires air for its sustenance, a fact which, although by no means generally admitted, found supporters from the time of Hero of Alexandria. One of the first air-pump experiments tried by Otto Von Guericke was for the purpose of ascertaining whether a candle would continue to burn in an exhausted receiver; and Boyle, in his first pneumatic treatise, (1660,) mentions several proofs that combustion cannot proceed in a space void of air. In an essay on this subject,* published by Boyle in 1672, we find hydrogen for the first time recognised as an inflammable body. Among other experiments, he poured upon iron filings "a saline spirit, which, by an uncommon way of preparation, was made exceeding sharp and piercing;" immediately "fumes" were given off, which proved to be inflammable. When allowed to burn within an air-pump receiver, the flame suddenly enlarged itself on exhausting, and then went out altogether. Boyle does not appear to have studied the properties of the new gas, but contents himself with suggesting that it consists either of "the volatile sulphur of Mars, or of metaline steams participating of a sulphurous nature."

* "On the Difficulty of Preserving Flame without Air."

Boyle also published in 1672 an essay entitled "*Fire and Flame Weighed in a Balance,*" in which are detailed a number of experiments made to determine the amount gained by certain metals during calcination. We have previously* considered at some length John Rey's important treatise on this subject, published forty-two years earlier. One of the first papers read before the Royal Society (February 23, 1661) was "*On the Weight of Bodies Increased in the Fire.*" The experiments were made by Lord Brouncker at the Tower of London, and are given in detail in Sprat's "History of the Royal Society;" but they are by no means concordant—so little so, indeed, that it was not considered as a proved fact that metals gain weight at all during calcination; for we find on March 20, 1661, "The amanuensis was ordered to make the experiment of the calcination of antimony whether it increaseth or not, and to weigh it before and after, in and out of the water."

Boyle found that an ounce of copper filings, heated to redness for two hours, gained forty-nine grains, while an ounce of tin gained one drachm during calcination. Tin and lead heated in hermetically sealed vessels, underwent partial calcination, from which Boyle inferred that "glass is pervious to the ponderous parts of flame," and that the gain of weight during calcination arises from "extinguished flame" assimilated by the calx. Boyle reduced lead from its calx; hence he considers a calx neither the "caput mortuum" nor the "terra damnata" of the body calcined, as was generally believed, but rather as the body submitted to calcination *plus* something absorbed during calcination. It is curious that Boyle, who had worked upon the air with certainly more assiduity than any of his contemporaries, should not have attributed the increase of weight of calces to the action of the air upon the body calcined; more especially as in a treatise published in 1674 ("*Suspicions about Some Hidden Qualities of the Air*") he mentions that marcasite, when exposed to the air, becomes covered with a body of a vitriolic nature. He also considers that the efflorescence on walls comes from the air, and suggests there is a something of a solar or astral nature, possibly "a volatile nitre," dispersed throughout the air, and necessary for the sustenance of life and flame. As an additional reason for believing that there is some "hidden quality" in the air, he mentions that he made a liquid of "sublimate copper and spirit of salt," which was of a dirty, red color so long as it was kept in a closed phial, but when exposed to the air it changed to "a green exceedingly lovely."

I have mentioned above Boyle's supposition that there is "*a volatile nitre*" in the air, and this leads us to the consideration of that which I conceive forms the basis of pneumatic chemistry—the recognition of a connexion between the air and nitre. We shall find as we proceed the vast importance of the experiments which were made to determine the nature of that connexion.

Let us first understand how such dissimilar bodies came to be classed together. In the *Novum Organum*, Bacon urges the necessity

* *Chemical News*, vol. x., p. 208.

of collecting together what he calls "a number of instances agreeing in one form." "Inquisitio formarum," he writes,* "sic procedit; super naturam datam primo facienda est comparentia ad intellectum omnium instantiarum notarum, quæ in eadem natura conveniunt, per materias licet dissimillimas." Following out this last clause to the very letter, Bacon takes the heat of the sun as the first "instance agreeing in the form of heat," and classes with it the skins of animals and oil of vi triol, on the ground that the former (as he supposed) contained heat, and the latter burnt linen. On the same principle (and certainly with equal reason) some philosophers traced a relationship between the air and nitre:—nitre, when thrown upon red-hot coals, produces very intense ignition; a blast of air directed upon red-hot coals produces the same effect, the two instances obviously "in eadem natura conveniunt, per materias licet dissimillimas." This mode of procedure may appear crude and likely to mislead, when we consider Bacon's classification of instances agreeing in the form of heat, but it must be remembered that he gives negative instances which qualify the former, and enable the mind to decide whether certain instances, which appear at first sight to agree, may really be admitted as such. Moreover, the classification is only to be temporarily made, and then to be tested rigidly by experiment. The classification of the air with nitre (as also Newton's familiar classification of the diamond with combustible bodies) belong to that class of instances called by Bacon "instantiæ conformes sive proportionatæ," which he defines as "primi et infimi gradus ad unionem naturæ," leading the mind "ad axiomata sublimia et nobilia."†

Nitre has always been an important salt. It was known in the East from very early times, and after the invention of gunpowder was largely imported into Europe. Geber, the earliest writer on chemistry, (8th century,) mentions both nitre and nitric acid, and the former figures prominently in all alchemical and old chemical treatises. It was called *saltpetre* from the fact of its being found adhering to rocks (πετρος). Bacon attributes the force of gunpowder to the nitre which it contains, "which, having in it a notable, crude, and windy spirit, first, by the heat of the fire, suddenly dilateth itself, and we know simple air, being preternaturally attenuated by heat, will make itself room, and break and blow up that which resisteth it; and, secondly, when the nitre hath dilated itself, it bloweth abroad the flame, as an inward bellows."‡

Shortly after the establishment of the Royal Society, Mr. Henshaw (one of the first elected Fellows) read a paper before the Society "On the History of Nitre,"§ in which he says it is probable "that the air is everywhere full of a volatile kind of nitre" generated in the clouds, inasmuch as he has found it in dew and rain. He was informed, however, that no earth yields so much as that of a church-

* *Nov. Org.* Lib. 2, Aph. 11. † *Nov. Org.* Lib. 2, Aph. 27.

‡ "Sylva Sylvarum. A Natural History in Ten Centuries." Cent. 1, par. 30.

§ Read August 14, 1661, and printed in Sprat's "History of the Royal Society."

yard, a fact which militated somewhat against his theory. He speaks of nitre as "the darling of nature, the very basis and generation of nutriment." In a history of nitre written by one William Clark, and published in 1670, we find a section with the rather startling title "A Chemical Analysis of Nitre." Nitre was heated in a retort with potters' earth, when red vapors, smelling like aquafortis, and known as "the flying dragon," were copiously evolved—an analysis, indeed, in the broadest sense of the word, but scarcely justifying the title of the chapter describing it; for we must remember that a hundred years later the term "chemical analysis" could not justly be applied to any operation or series of operations in the chemistry of the period. Clark considers that thunder, lightning, and meteors are caused by nitre in the air; Sennertus attributed thunder and lightning to the meeting of nitrous and sulphurous vapors, an idea evidently originating from the knowledge of the composition and properties of gunpowder. Clark attributes the propulsive force of gunpowder to the sudden conversion of the nitre it contains into air. He mentions the fact that nitre was used by chemists for converting some metals into calx, and he considers that metals become rusted when exposed to the air on account of the nitre which it contains. The latter part of Clark's history of nitre is devoted to the statement of some remarkably wild and useless speculations. In one chapter the author proposes, and endeavors to support the supposition, "That the fiery rain of brimstone and fire on Sodom and Gomorrah was lightning, and that nitre is expressed by the word fire."

Boyle, in a short essay, entitled "*A Fundamental Experiment with Nitre*," mentions that he prepared pure nitre by crystallization, melted it in a crucible, and threw red-hot cinders into the molten mass until deflagration ceased. He then added "spirit of saltpetre" to the residue, and set aside to crystallize. The crystals were found to resemble saltpetre in every respect. He also prepared nitre by mixing "common potashes and aquafortis" and crystallizing.

Although a certain relationship between the air and nitre was very generally admitted, philosophers were by no means agreed as to the form and character of that relationship. Some maintained that the effects produced by the air are due to its containing nitre, others that the effects produced by nitre are due to its containing air. Thus, Hobbes and others considered that nitre consists of "many orbs of salt filled with air;" Gassendus, in common with a large number of philosophers, maintained that particles of nitre are diffused throughout the atmosphere; while Hooke, in his ingenious and philosophical theory of combustion,* affirms that the portion of the air which renders it the solvent of combustible bodies, "is like, if not the very same, with that which is fixed in saltpetre."

It has always been a matter of regret to us that Hooke's theory of combustion has received so little attention at the hands of the scientific. It was only last year that M. Chevreul (an authority on matters relating to the air) wrote in the *Comptes Rendus*, "On doit a Stahl

* See the tenth of these papers, *Chemical News* for February 17, 1865.

la Premiere Explication de la Combustion."* The theory of Stahl, unsupported either by experiment or sound reasoning, cannot be compared with the theory of Hooke, based upon experimental results, and supported by just and accurate reasoning. Hooke clearly showed the part which air plays in combustion; Stahl adopted the phantasy phlogiston. Then, as to priority, Hooke's theory was perfected when Stahl was in his cradle, and was published when he was four years old. Hooke's theory was neglected simply because it was so little known, and this was owing to the manner in which it was given to the world. Not published separately, it was not even designated a new theory of combustion. It forms part of an article on "charcoal or burnt vegetables" in the *Micrographia*, a work in which we should scarcely look for a new theory of combustion, inasmuch as it professes to detail "some physiological descriptions of minute bodies made with magnifying glasses." Moreover, there is nothing to guide the reader to the subject, and without reading the whole book he would not be likely to meet with it, for it is buried in a mass of irrelevant matter. It is, I conceive, in the causes given above that we must seek for an explanation of the fact that one of the most original and complete theories which has ever appeared in the history of science, was all but unknown in its own period, and has remained almost unnoticed down to the present day.

We have next to consider the important treatise "De Sal-nitro et Spiritu Nitro-aëreo" of John Mayow, the first of the five great works on pneumatic chemistry which were published before the discovery of oxygen.

* "Note historique sur les manieres diverses dont l'air a été envisagé dans ses relations avec la composition des corps."—*Comptes Rendus* for December 12, 1864.

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*On the Origin of Carbides and Combustible Minerals.**

By M. BERTHELOT.

From the London Chemical News, No. 341.

There is, in most instances, no difference of opinion as to the origin of combustible minerals—that is, when they are evidently derived from transformed organic matters. But is this the case under all circumstances? The carbides, petroleums, and bitumens, disengaged from the crust of the earth, often in great abundance, incessantly and from depths apparently lower than the stratified earth, do they always and necessarily result from the decomposition of a pre-existing organic substance? Is this the same with the carbides so frequently observed during eruptions and in volcanic emanations, and to which M. Ch. Sainte Claire-Deville has latterly called attention? Finally, should the same origin be assigned to the carbonaceous matters and carbides of hydrogen contained in certain meteorites, which seem to have an origin foreign to our planet? These are questions about which several distinguished geologists are still undecided. Without pretend-

* *Comptes Rendus*, vol. lxii., p. 949.

ing to decide so difficult a point, it seems to me interesting to find how the natural carbides of hydrogen may be formed synthetically—that is to say, by purely mineral reactions of the same kind as geologists have observed to take place between the substances contained in the interior of the globe, and those constituting its crust.

We will admit, according to M. Daubrèe's recent hypothesis, that the interior of the earth contains free alkaline metals. This single hypothesis, added to the experiments I recently published, almost necessarily leads to the explanation of the formation of carbides of hydrogen.

In fact, carbonic acid, everywhere infiltrated through the terrestrial crust, must come in contact with alkaline metals at a high temperature, and form acetylides in the same manner as in my experiments. These same acetylides may also result from the contact of earthy carbonates with alkaline metals even below dull red heat.

Now, these alkaline acetylides once formed will undergo the action of aqueous vapor. Free acetylene would hence result were the products immediately submitted to the action of the heat, and of hydrogen* and other bodies which might be present. But by reason of these diverse conditions acetylene will not be produced, as my recent experiments show. In its place are obtained, either the products of its condensation, which resemble bitumens and tars, or the products of the reaction of hydrogen on these already condensed bodies—that is to say, carbides more hydrogenated. There is scope for almost unlimited diversity in these reactions, according to the temperature of the bodies present.

The formation, in a purely mineral way, of all natural carbides may easily be conceived, and the formation would, moreover, be continuous, as the reactions causing it renew themselves incessantly.

The generation of carbonaceous matters, and of the carbides contained in meteorites, may be explained in the same way, provided it be admitted that these meteorites originally belonged to the planetary masses.

These hypotheses might be further developed, but I prefer to keep within the limits authorized by my experiments, and merely state geological possibilities.

* Produced at the same moment by the reaction of the water on the metals.

Cold Bleaching Process.

From the London Journal of the Society of Arts, No. 716.

M. Tessié du Mothay and M. Rousseau describe very satisfactory trials which they have made of a cold bleaching process, by means of which all textile materials, whether silk, cotton, linen, flax, wool, or any woolly fibre can be bleached. The agent employed is a permanganate of soda, slightly acid, prepared by a new and economical process. With this salt, the extraordinary properties of which have of late years been much studied, a bath is prepared, in which the materials to be

bleached are dipped. They are stirred about with a glass rod from time to time, and after about ten minutes they are taken out of the bath, strongly colored of a violet brown hue by an abundant deposit of oxide of manganese. They are then dipped as quickly as possible in a bath of water, acidulated with sulphurous acid, and again stirred and turned over with a glass rod, and after two or three minutes the materials or thread, originally of yellow or gray color, are already white. These operations are repeated twice more, and the result is a brilliant white, whilst the fibres are in no way injured. The materials operated upon were cotton fabrics, dirty as they came direct from the loom, as well as skeins of linen thread of a dark slate-color, which, by existing processes, would have taken many days to bleach.

Simple and Economic Process for obtaining Soda from Common Salt.

From the London Chemical News, No. 347.

Mr. Walter Weldon has taken out patents for a process described as follows: The new process consists in placing within a vessel capable of resisting the required pressure, an equivalent of common salt, and another of carbonate of magnesia, with a small quantity of water, and then pumping into the vessel the carbonic acid formed by causing atmospheric air to traverse coal in a state of ignition. The carbonate thus becomes bicarbonate of magnesia, which dissolves in the water, and then decomposes the chloride of sodium, chloride of magnesium, which remains in solution, and bicarbonate of soda, which precipitates, being formed. The whole process lasts but a quarter of an hour at most, and the cost is only that of the coal used in forming the carbonic acid. A moderate heat drives off the second atom of carbonic acid from the bicarbonate of soda, changing it into carbonate, and the magnesia may be recovered from the chloride by evaporating the solution containing it to dryness, and raising the residue to a temperature below redness.

On the Combustion of Gas for Economic Purposes. By Dr. LETHEBY.

From the London Chemical News, No. 344.

(Continued from page 249.)

The temperature of different combustibles is shown on the diagram below, and you will notice that the highest temperature produced by the various constituents of coal gas is that of acetylene, or the vapor of benzole when burned in oxygen, the heat of which exceeds 17,000° Fahr. The lowest temperature of all the constituents is about 12,700° Fahr., the temperature of burning carbonic oxide.

On the same diagram I have tabulated the thermotic power of a great number of substances. It is expressed in the number of pounds of water raised 1° Fahr. by a pound of the substance, and when the body is capable of being converted into gas or vapor, I have also expressed it in the cubic foot at common temperature and pressures.

Hydrogen, you perceive, is the most powerful thermotic agent, and carbonic oxide is the weakest. A pound of the first of these gases will raise 62,030 lbs. of water 1°, whereas a pound of the latter will only heat about 4325 lbs. of water to that extent. Examined by the cubic foot, and considering that for every pound of water raised 1°, about 48 cubic feet of air are raised to the same extent, we may say the chief constituents of coal gas have this thermotic power—

Pounds of Water and Cubic Feet of Air raised 1° Fahr. by a Cubic Foot of the Gas burning in Air.

Cubic foot of—		Lbs. water raised 1° Fahr.	Cub. ft. air raised 1° Fahr.
Hydrogen	heats.	329	15,837
Marsh gas	"	996	47,946
Olefiant gas	"	1585	76,299
Propylene	"	2376	114,378
Butylene	"	3168	152,502
Acetylene	"	1251	60.2.0
Benzole vapor	"	3860	185,814
Carbonic oxide gas	"	329	15,403
Common coal gas	"	650	31,290
Cannel coal gas	"	760	36,585

From this we can determine the practical thermotic power of any of these agents. A cubic foot of common gas will heat 65 gallons of water 1°, or 6·5 gallons 10°, or 3·25 gallons 20°; so that a bath containing 250 gallons of water would require about 77 cubic feet of common gas, or 66 of cannel, to raise its temperature from 55° to 75°. In practice, however, this is rarely attained, because of the faulty construction of the heating apparatus. I find, indeed, that a bath in my own house, made by Phillips, of Skinner Street, takes nearly twice this proportion of gas to heat it, and being in a closed room the atmosphere is almost poisoned before the bath is ready; and the circulation of the hot water is so imperfect that the top layer becomes boiling hot before the bottom of the water is warm. This is a subject which requires attention, for it is open to much improvement.

Again, with regard to the boiling power of gas, although in good practice a cubic foot of gas should boil off about 4712 grains of water, or about 22 times its own weight, yet this is not often attained, for in an open vessel we rarely evaporate more than 2866 grains of water, or about 13 times its weight.

But the heat of the burning gas is more surely applied to the warming of rooms; for, as you will see by the table, a cubic foot of common gas will heat an apartment containing 3129 cubic feet of air 10°, and the same quantity of cannel gas will heat 3658 cubic feet to the same extent. Other illuminating agents will, however, light for light, heat the atmosphere, and vitiate it to a larger extent. This is seen in the table which I brought under your notice at the last lecture.

TABLE *of the Combustion, Temperature, and Explosive power of Gases.*

	Per lb. substance.			Pounds of water heated 1° Fahr.			Temperature of combustion.				Explosive power.		Mechanical power per lb.
							Open flame.		Closed vessel.				
	Ox. used.	CO_2 produced.	Air vitiated.	Per lb. substance.	Per cub. ft. substance.	Per lb. ox. used.	With ox.	With air.	With ox.	With air.	With ox.	With air.	Tons raised 1 ft. high.
	Cub. ft.	Cub. ft.	Cub. ft.	Lbs.	Lbs.	Lbs.	Deg.	Deg.	Deg.	Deg.	At.	At.	Tons.
Hydrogen	93·4	0·0	467	62030	329	7754	14510	5744	19035	7852	25·6	12·5	21390
Marsh gas	47·2	23·6	829	23513	996	5878	14130	4762	18351	6680	37·0	14·0	8408
Olefiant gas	40·5	27·0	878	21344	1585	6225	16535	5217	21344	7200	42·9	15·1	7360
Propylene	40·5	27·0	878	21327	2376	6220	16522	5239	21327	7177	67·3	22·5	7360
Butylene	40·5	27·0	878	21327	3168	6220	16522	5232	21327	7177	85·8	30·2	7360
Acetylene	36·3	29·1	909	18197	1251	5914	17146	5142	22906	7099	37·9	17·6	6275
Benzole	36·3	29·1	909	18197	3860	5915	17146	5142	22906	7099	113·7	52·8	6275
Carbonic oxide	6·7	13·5	371	4325	320	7569	12719	5358	16173	7225	21·8	11·7	1490
Bisulph. carbon	14·9	5·0	689	6120	1219	4845	15280	4314	20031	5917	30·2	11·6	2110
Sulph. hydrogen	16·7	0·0	639	7444	671	5271	13088	4388	17542	6026	28·3	12·7	2567
Cyanogen	14·5	14·5	435	6712	925	5142	13488	5028	17645	6167	35·6	17·8	2314
Common coal gas	37·5	17·6	618	21060	650	6816	14320	5228	18101	7001	29·2	14·6	7262
Cannel gas	31·0	22·0	698	20140	760	6503	14826	5121	19046	7186	38·8	18·0	6945
Wood spirit	25·3	11·8	422	9547	819	6363	11435	4641	14902	6347	40·3	15·3	3230
Alcohol	24·6	16·4	533	12929	1597	6195	13305	4831	17223	6629	46·4	16·2	4455
Ether	30·9	20·4	664	16249	3217	6158	14874	5150	19225	6953	58·6	19·0	5603
Camphene	38·9	27·8	880	19573	7134	5942	16271	5026	20953	6922	47·6	16·0	6750
Spermaceti	37·0	25·2	815	17589	. .	6088	14599	4413	. .	. .	. .	. .	6065
Wax	37·7	25·6	829	15809	. .	4995	12921	4122	. .	. .	. .	. .	5451
Stearic acid	34·6	24·0	783	17050	. .	6061	15885	4818	. .	. .	. .	. .	5880
Stearine	34·4	14·2	527	18091	. .	6143	15815	5095	. .	. .	. .	. .	6207
Paraffin	40·5	27·0	878	21327	. .	6220	16522	5239	. .	. .	. .	. .	7354
Paraffin oil	40·5	27·0	878	21327	. .	6220	16522	5239	. .	. .	. .	. .	7354
Rape oil	38·7	24·3	801	17752	. .	6123	15839	5087	. .	. .	. .	. .	6121
Sperm oil	38·7	24·3	801	17230	. .	6088	15363	4937	. .	. .	. .	. .	5941
Carbon	31·0	31·5	943	14544	. .	5447	18329	3026	. .	. .	. .	. .	5015

Heating and Vitiating Effects of Different Illuminating Agents when burning so as to give the Light of 12 *Sperm Candles.*

	Lbs. water raised 1° Fahr.	Oxygen consumed, cu. ft.	Carb. acid produced, cu. ft.	Air vitiated, cu. ft.
Cannel gas	1920	3·30	2·01	50·2
Common gas	2786	5·45	3·21	80·2
Sperm oil	2335	4·75	3·33	83·3
Benzole	2326	4·46	3·54	88·5
Paraffin	3619	6·81	4·50	112·5
Camphene	3251	6·65	4·77	119·2
Sperm candles	3517	7·57	5·77	131·7
Wax	3831	8·41	5·90	149·5
Stearic	3747	8·82	6·25	156·2
Tallow	5054	12·00	8·73	218·3

The vitiating effect is calculated on the actual loss of oxygen, and on the power which 4 per cent. of carbonic acid has on the vital qualities of the atmosphere; and, though the results indicate that there should be less discomfort in a room lighted with coal gas than with any other illuminating agent, yet common experience is altogether in the opposite direction. The explanation of this is to be found not only in the fact that gas is used more lavishly than other agents, but also that in burning it produces a larger proportion of aqueous vapor, which, becoming diffused into the surrounding atmosphere, occasions great discomfort. Professor Tyndall has shown that the molecules of aqueous vapor are endowed with a remarkable power of absorbing the radiant heat of burning gas, and by thus becoming warm they create a sense of oppression. And again, when the warm atmosphere of a room is overcharged with moisture, it checks the action of vaporous or insensible perspiration, and this also causes distress. In all cases, therefore, where gas is largely used in rooms, provision should be made for the quick removal of the products of combustion.

When the heat of gas is required for warming a room, its radiant power should be increased by allowing it to ignite some solid substance, for the radiant heat of a non-luminous flame is very insignificant. I have here a Bunsen's burner, which gives with this gas the highest temperature of combustion, but the amount of heat which radiates from it is very small—smaller, indeed, than is the case when the gas is burnt in the ordinary way, when every atom of ignited carbon becomes a centre of radiation. The proportion of radiant heat from the same flame under different circumstances is very variable. From Bunsen's burner it is only 12, from the same gas burnt as a luminous flame it is 30, and with a spiral platinum in it it is 85. The introduction of solid matter into a non-luminous flame of high temperature changes its character altogether, and from the heat of convection it becomes heat of radiation. No doubt the quality of the vibrations is greatly changed, and they pass from the large and compara-

tively slow undulations of obscure heat to the small and quick vibrations of light; and the more this is affected, the greater and greater becomes the intensity of the radiant heat. Prof. Tyndall found that the following were the quantities of radiant heat from a platinum spiral, at different degrees of luminosity:

	Degress of heat radiated.
Platinum spiral, feebly red	19
" " dull red	25
" " full red	62
" " orange red	88
" " yellow red	158
" " yellow white	200
" " blue white	276
" " intense white	440

So that, when we wish to economize the radiant heat of burning gas, it is best to use it with some solid body, as fragments of pumice or pieces of asbestos.

The last point to which I would refer is the available or convertible motive power of burning gas.

The calculations of Dr. Mayer of Heilbron, and the experimental inquiries of Mr. Joule of Manchester, show that the mechanical power of heat is 772 lbs. raised a foot high for the heat necessary to raise the temperature of a pound of water 1° Fahr. A cubic foot of hydrogen in burning has, therefore, the mechanical power of ($329 \times 772 =$) 253,988 lbs.; and the same quantity of common gas has the power of ($650 \times 772 =$) 501,800 lbs.; while the power of a cubic foot of cannel gas is ($760 \times 772 =$) 586,720 lbs., raised a foot high. But if the same quantity of these gases is exploded with air or oxygen in a closed chamber, the mechanical power is somewhat different. I have here tabulated the expansive force of such a mode of combustion, and I may say that the calculations are deduced from the temperatures of combustion and from the volumes of the products, allowance having been made for the specific heats of the several products. It would seem, therefore, that the explosive powers of the several constituents of coal gas, when mixed with their proper proportions of air or oxygen, are as follows:

Explosive Power of Mixed Gases.

	Mixed with air. (Ats.)	Mixed with ox. (Ats.)
Hydrogen	12·5	25·6
Marsh gas	14·0	37·0
Olefiant gas	15·1	42·9
Propylene gas	22·5	67·3
Butylene gas	30·2	85·8
Carbonic oxide	11·7	21·8
Common gas	14·6	29·2
Cannel gas	18·0	38·8

These are the theoretical pressures exerted upon the sides of the containing vessel when these several gases are exploded with their proper proportions of air or oxygen; but as the explosion is never instantaneous, but proceeds from particle to particle, and therefore occupies time, and as the walls of a vessel always cool the products of the exploded gas to a great degree, this theoretical value is never obtained in practice, the highest pressure in the exploding chamber of a gas engine being only 75 lbs. on the square inch, or five atmospheres. The power of this has been determined experimentally by Mr. Evans, who informs me that, with a cubic foot of a mixture of 9 air and 1 gas, he has propelled a wooden shot (3 inches by 4) 50 yards; and he ascertained that the same effect was produced with an ounce of gunpowder. The motive power, therefore, of the exploding mixed gas is considerable.

In the gas engines of Lenoir it has been found that the best proportions of air and gas are eight volumes of air to one of common gas; theoretically the best proportion for London (13-candle) gas is 5·6 volumes of air to 1 gas. A larger portion of air is required for cannel gas, as 11 to 1; but in practice it is found that cannel gas does not produce so good an effect as common gas. The time of the explosion is about the twenty-seventh part of a second, and the temperature of it is about 2474° Fahr. instead of from 5228° to 7000°, the calculated temperatures for open and closed chambers.

The machines which are used for practically employing this power are all modifications of the original engine of Lenoir. They consist of a cylinder with a double-action piston, receiving the mixed gas alternately on either side of the piston. The arrangement is such that, in the movement of the piston, the air and gas, in proper proportions, (8 to 1,) are drawn into the cylinder by a suitable side valve, and when the piston has made half a stroke it shuts off the valve; at that moment the mixed gas is fired in the cylinder by means of an electric spark from a Ruhmkorff's coil passing between the points of two wires in the cylinder. One of these wires is insulated by traversing a rod of porcelain fixed in the cylinder, and, being in connexion with a make-and-break contrivance, called a distributor, attached to the fly-wheel of the engine, it receives the charge of electricity, and so fires the mixed gas at the right moment. The expansion caused by the explosion and heat of combustion drives the piston through the rest of the stroke, and it generally ends with a good deal of unutilzied pressure. In one case I find that the indicator recorded an initial pressure of 75 lbs. on the inch at the moment of explosion, and a final pressure of 25 lbs. The loss of power in this case must have been considerable, for not only is there the loss of the difference (12·5 lbs.) between the calculated pressure, 37·5 lbs., (75 ÷ 2,) and the real, (25,) but there is also the total loss of the unavailable final pressure. A part of this loss is no doubt due to leakage, and to the cooling effect of the walls of the cylinder; for the temperature has been observed to fall from 2474° Fahr., at the moment of explosion, to 1438° at the end of the stroke, the calculated temperature being 2156°. Indeed, the management of the temperature is one of the difficulties of the engine, for the

cylinder has to be cooled by a stream of water. Improvements will no doubt be made in the construction of the engines, and especially in the utilization of the residual power, and this must be done by shutting off the valve and firing the gas earlier in the stroke. This has already been done to some extent in America with engines of half horse power, as with cylinders of $4\frac{5}{8}$-inch diameter by $8\frac{3}{4}$-inch stroke; and this with 185 revolutions, or 370 explosions, in a minute, raises 16,280 lbs. 1 foot high in a minute. In France and in this country much larger engines are made, as from 1 to 3 horse power.

The quantity of gas used in the working of the engine is rather variable. In the American engine, already alluded to, it took 105 cubic feet of gas an hour to work an engine of half horse power, and a one horse engine in London takes about 185 cubic feet of London gas—say it is 200 cubic feet—per horse power. This is 1,980,000 lbs. a foot high; whereas the theoretical power of 200 feet is more than 100,000,000 of lbs.

The advantages of the engine are very great; for it takes up but little room, it is very clean, it works with great regularity, it requires little or no attention, and it costs nothing for fuel when it is not at work.

One thing I ought to mention in speaking of the explosive power of mixed gas, and that is the effect of using mixtures in improper proportions. Sir Humphrey Davy found, in his experiments with marsh gas, that there was but one proportion of air and gas which gave the maximum effect, and that was a mixture of 1 of gas and 7·5 of air, (theoretically it should be 1 to 9·5.) When the proportions are reduced in either direction the mixture becomes less and less explosive, until with 1 gas and 15 air, or with equal volumes of gas and air, the mixture ceases to explode.

In the case of coal gas, although the theoretical proportions for London gas are 1 of common gas* to 5·6 of air, and 1 of cannel gas to 7·4 of air, yet the best results are obtained with 1 of the former to 8 of air, and 1 of the latter to 11. On either side of this proportion the mixture rapidly becomes less and less explosive.

The effect of mixing other gases with explosive mixtures has been well studied by Davy and others. Taking, for example, an explosive mixture of 2 volumes of hydrogen and 1 of oxygen, it is found that 1

* *Average composition of London gas by volume.*

	Common gas.	Cannel gas.
Hydrogen	46·0	27·7
Light carburetted hydrogen	39·5	50·0
Olefiant, &c.	3·8	13·0
Carbonic oxide	7·5	6·8
Carbonic acid	0·7	0·1
Aqueous vapor	2·0	2·0
Nitrogen	0·5	0·4
	100·0	100·0

of nitrogen to 6 of the gas, or 1 of carbonic acid to 7 of it, will stop its explosion.

Lastly, the temperature at which these gases are fixed is a matter of considerable importance. Davy found that he could not set fire to marsh gas, (the fire-damp,) or to an explosive mixture of it with air, by using the strongest heat of glowing charcoal. He even blew a mixture of the gas upon glowing charcoal until he got it at a maximum heat, without firing it; nor can it be fired by the sparks from flint and steel. Not so, however, with hydrogen, or olefiant gas, or carbonic oxide, all of which are fired by the sparks and by glowing charcoal—perhaps the igniting temperature is about 3900° Fahr., and the vapor of bisulphide of carbon is fired at as low a temperature as 300° Fahr. These facts are deserving of attention; for they show that gas leaking from the mains may be fired by a spark from a pick, or from the chipping of a hole in the pipe in laying a service.

And now, gentlemen, we have gone over the question of the phenomena of gaseous combustion, and of the manner in which gas is to be most profitably and most economically used for illuminating purposes. We have also examined the thermotic powers of coal gas, and I hope if I have the opportunity of meeting you again, I shall be able to bring under your notice one other question of interest to gas engineers, and that is the profitable utilization of the waste products of gas-works.

MISCELLANIES.

Effect of Forests on the Temperature of the Air.—The MM. Becquerel, in an elaborate memoir upon this subject, presented to the Academy of France, reach the conclusion that the temperature is higher away from the forest than within it, and higher within than immediately around it. The mean temperature of the trees appear to be that of the surrounding air; but changes take place much less rapidly in the trees, especially in the trunks. The phenomena of vegetation do not appear to influence the temperature, for the temperature of the leaves scarcely differs at any time from that of the air. A singular observation is that forests have the property of preserving tracts lying to leeward of them from hail. The windward edge of the forest is frequently attacked, but the hail becomes less and less as it penetrates the forest, soon ceases, and is not reproduced for some distance from the leeward edge.

Capillary Attractions.—This subject has attracted the particular attention of the distinguished chemist M. Chevreul, whose position as director of the government establishment for the manufacture of Gobelin tapestry has already led him to a number of very important investigations, especially those in reference to the harmony and contrast of colors. The phenomena of dyeing appear to have led him to his present researches, which were conducted in reference to the absorption

of linseed oil and water by powdered kaolin, common clay, and white lead. His conclusions are, that there is in capillarity an elective attraction, and that the linseed oil has a higher *capillary affinity* for white lead than water has, but that water has the higher *capillary affinity* for kaolin and clay. He proceeds to apply these facts to the explanation of a number of phenomena in nature and in the arts.

Testing of Ships' Compasses.—A M. Gilbert Govi suggests, through the pages of the *Cosmos*, a very simple means of ascertaining whether a ship's compass has had its poles reversed by a stroke of lightning. It consists simply in making a galvanic couple by plunging a small plate of zinc and one of copper into sea-water, and connecting them by means of a copper wire. This wire being held close above the needle will deflect it. Ampere's rule for remembering the direction of the needle is as follows: Suppose the observer to be lying on the connecting wire looking towards the needle, the end connected with the copper plate being at his feet, the zinc end at his head. The north end of the needle is thrown towards the left. This will in any case determine the position of the poles of the needle, or if the wire be wrapped in a helix around a bar of soft iron, this wire becomes magnetic, the poles being so adjusted that, if looking from the copper towards the zinc end the wire winds direct, (that is in the direction in which the hands of a watch move, or from left over to right,) the end towards you is the south end. By placing the needle in a coil of this kind, if its magnetism has been destroyed by the flash it may be restored in a few minutes.

M. Govi further recommends, if the means of constructing the galvanic couple be not at hand, to take a bar of soft iron, heat it white hot so as to destroy all magnetism which it may possess, and after it has cooled hold it in a vertical position, near the two ends of the needle successively. A bar of soft iron held vertically becomes temporarily magnetic; in the north magnetic hemisphere, its lower end becomes a south pole, in the south magnetic hemisphere a north pole. This latter expedient will answer very well, provided the ship is not too near the magnetic equator, which is, unfortunately, precisely the region where the accident is most apt to occur.

Duration of the Impression of Light on the Eye.—Abbé Laborde describes a curious experiment which seems to show that the more refrangible rays of the spectrum make a more durable impression on the retina than those less refrangible. A beam of sunlight is admitted into a dark chamber through a narrow slit, (6 millimetres by 3 millimetres.) In its path is adjusted a rotating disk of metal having slits cut in its circumference so that the beam may be passed and stopped alternately as the disk turns. The observer is placed behind a ground glass screen upon which the beam when passed is received. A brake on the axis of rotation allows him to adjust the velocity of the disk. At low velocities the appearances of the beam follow each other slowly, and can be distinguished. The light being white, as the velocity increases, the

image becomes tinged with color in the following order: Blue, green, rose, white, green, blue. After the second blue, the image appears white at all velocities. The experiment is curious and would seem easy to repeat.

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Water of the Dead Sea.—This curious inland water, equally interesting on account of its history and its physical peculiarities, has been recently thoroughly explored by the Duc de Luynes. Contrary to the general belief, he found in the southern portions of it, around the ruins of Sodom, fishes who appeared to be living and multiplying their species comfortably. M. A. Terreil, who accompanied him, procured a number of specimens of the water from various localities and at different depths, and M. Daubree has analyzed them and communicated his results to the Academy of Sciences of Paris. The following are his general conclusions:

1. The density of the water of the Dead Sea increases with the depth.

2. The composition of the water is not identical throughout its extent, even when those localities near the mouth of the river and the small streams which enter it are excepted. Thus, the water taken five miles to the east of Ouadi Mrabba contains four times more lime than that taken five miles east of the Ras Feschkah; but the latter contains twice as much sodium as the former.

3. The concentration of the water is also very variable in different localities.

4. The water collected to the north of Sodom, in the part which forms a lagoon, contains more chloride of sodium than chloride of magnesium. which is the reverse of the ordinary character of the waters of the Dead Sea, and explains the possibility of fishes living there.

5. The proportion of the saline matters remains the same at all depths; except that the bromides appear to concentrate at depths of 300 metres.

6. The water of the Dead Sea appears to contain no iodine nor phosphoric acid.

7. The spectroscope detects in the dried salts neither lithium, cœsium, nor rubidium. It contains but little sulphuric acid, but is composed almost exclusively of chloride of magnesium, sodium, calcium, and potassium, and of a certain quantity of the bromides of these bases. Their relative richness in bromine and potassa is such as to deserve the attention of manufacturers of these articles.

8. The waters of the rivers and springs around the Dead Sea are composed of chlorides, sulphates, and carbonates of lime, magnesia, soda, and potassa, and contain no bromine appreciable to analysis.

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Photo-lithography.—M. Pinel Peschardiere has communicated a new process for transferring photographs to stone, to the French Photographic Society. The process is not very distinctly described in the *Cosmos*, whence we take the notice, but seems simple and effective within the limits in which Mr. Osborne has already succeeded so well,

that is, in the production of engravings. Are we ever to have his process accessible and on a practical scale?

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Cheap Meat.—The peculiar climatic and financial conditions of our country are, unfortunately, such that, notwithstanding the heroically virtuous efforts of our farmers or butchers, (exactly which, does not clearly appear; in fact, appears differently, according to the part of the market in which the question is asked,) the price of meat is continually rising, and it is evident that before very long our working classes will be brought to the condition of those in Europe, and be compelled to live without meat. In such a state of things we look with interest upon all methods of furnishing cheap meat to our markets, and call attention to a communication made to the Academy of Sciences, of Paris, by M. Vavasseur, detailing a method recently introduced in Uraguay, where heretofore myriads of cattle have been slaughtered yearly for their hides alone.

The animal is knocked in the head, bled with the greatest care, (an indispensable condition for the preservation of meat in hot climates,) skinned rapidly without blowing, and quartered. The meat, still palpitating, is cut up rapidly into slices from 5 to 6 centimeters (2 to 2½ inches) thick, and as large as possible. One of these is laid upon a bed of fine salt on a pine board, covered with a layer of the same salt; then another piece is laid upon it, and thus a pile is made as high as is convenient, which is left for about twenty-four hours, and then repiled in the inverse order with fresh salt, so that the lower pieces become the upper, and *vice versa*. After standing from twelve to fifteen hours more, the pile is again taken to pieces and the meat heaped up in a corner of the slaughter house in the open air, and merely covered with a piece of tarpaulin to protect it from the rain, sun, and dust. It remains here until sold. It is then subjected to the heaviest possible pressure, which, besides diminishing its volume, contributes efficaciously to its preservation, and is delivered in packages of 60 centimeters long, (24 inches,) 30 in breadth and height, weighing 100 Spanish pounds, (46·638 kilos. or 102·5 pounds,) which are wrapped carefully in bale cloth. The manner of using this meat is very simple. It is soaked for a dozen hours in fresh water, which removes the excess of salt, softens it, and gives it nearly the appearance of fresh meat. Boiled, it gives an excellent soup, and the meat is certainly preferable to the pork and salt beef in use in the navy. Cooked in other ways, and especially with vegetables, it furnishes an excellent nourishment. It can be sold to the consumers at 60 centimes the kilogramme (representing, after soaking, 1·5 kilos.) at the port of delivery, or 75 centimes at Paris. This would make the price in our currency, at Paris, about 7½ cents per pound of the material as delivered, or 5 cents per pound of the soaked meat.

Bearing upon this subject we find the following in the London *Daily News*, of September 28, (extracted by the New York *Tribune*,) and are glad to see that the subject is attracting attention in England. We should like to have a more full explanation of the Sloper-McCall pro-

cess, and do not implicitly believe in the "certain gas," which can be injected and preserve meat fresh for an indefinite period; but in the preservation itself we do fully believe, and in its vast importance to our working people. Will not some of our enterprising men look into the subject, examine the various processes proposed, and give us the benefits of their investigations?

"A very interesting *reunion* was held yesterday at the London Tavern, the object of which was the important one of ascertaining whether our present very deficient supply of animal food might not be supplemented from the illimitable Pampas of South America. The object of the meeting was stated by Mr. Paris, who explained that, at a previous social meeting held in the London Tavern, in November last, the advantages of an invention for preserving meat fresh were tested, and were pronounced to be successful. The inventors were Messrs. McCall and Sloper, and the process was the introduction of a certain gas, the nature of which is still the secret of the patentee, by means of which the meat was preserved fresh for any possible period. Armed with this invention, and provided with parcels of English beef cured according to the Sloper-McCall process, Mr. Paris proceeded to Buenos Ayres, and at a public entertainment there convinced all the local authorities that beef could be preserved perfectly fresh over the voyage to England. The government of Buenos Ayres, seeing the advantage that might accrue, gave Mr. Paris every facility for procuring the beef of the country, and it was some of this beef cured according to Mr. McCall's process that was served up at yesterday's luncheon. Before its introduction, Mr. Paris stated very candidly that the experiment was made under unfavorable circumstances, the present year having been a very bad one for cattle in La Plata. The agent of Messrs. Sloper and McCall having fallen sick, and been obliged to communicate the curing process to him, (Mr. Paris,) and the local workmen having put the beef into pans of pine wood instead of that which had no flavor of turpentine. The meat, however, was prepared under the inspection of Messrs. Zimmerman, the principal merchants of Buenos Ayres, and it now came before the London public, genuine South America beef of the Pampas, and preserved solely by the process patented by Messrs. McCall and Sloper.

"After this exordium, the luncheon, which consisted exclusively of Buenos Ayres beef, was put on the table in the various forms of roast, stewed, and in pies and puddings. The company ate heartily of the beef in all its varieties, and were unanimous in their approval of its freshness and flavor, giving, however, due credit to Mr. Nicholls, the eminent *chef* of the London Tavern, who had taken care that it should be dished to the best advantage. The roast beef was very fine, quite as good as the *filet de bœuf* of the first-class Paris *tables d'hôte*, and the stewed beef and puddings were admirable. There could be no doubt but that, if imported extensively, the La Plata beef, prepared according to the McCall process, would be a most valuable addition to the food of London, especially, as we can state, on the authority of Mr. Paris, that it could be sold by retail over the counter at prices varying from four-

pence-halfpenny to sixpence per pound, according to the capacity of the retailer. At the conclusion of the luncheon, cases of the raw meat which had been imported from Buenos Ayres were opened in presence of the company, and appeared and smelled as fresh as if they had been packed yesterday. It was, in fact, really good, succulent meat, and was unhesitatingly pronounced to be such by Mr. Warrener, the well-known preserver of fresh meat for the army. The importance of this process, as well as the labors of Mr. Paris in procuring a supply of the raw material, can hardly be overrated when we recollect that 2,500,000 of black cattle have up to the present date been annually killed in La Plata solely for the sake of their hides, the meat being left to the vultures, while we, in this country, have been paying famine prices for meat of not very superior quality. At the close of the proceedings, a resolution affirming the success of the process was proposed by Mr. Ravolta, and assented to by general acclamation."—*London Daily News.*

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Explosive Paper.—We take from Dr. Phipson's correspondence in the *Cosmos* the following directions for the preparation of this material, which may have its uses in the arts, and which, some time ago, in one of its forms, attracted considerable attention among us:

Take chlorate of potassa	9 parts.
" Nitrate of potassa	4½ "
" Ferro-cyanide of potassium	3½ "
" Wood charcoal, pulverized	3½ "
" Starch	½ part.
" Chromate of potassa	1/16 "
" Water	79 parts.

Mix the solid ingredients in the water, and boil for an hour, stirring well. Pass the paper through the solution, and dry at the temperature of boiling water. If intended for cartridges the paper is to be rolled into the cylinders before drying. The experiments tried with this substance, in comparison with gun-cotton, are said to have been favorable to it. It explodes only in contact with flame, is quick and powerful in its action, and does not leave any greasy residuum in the gun. It produces less smoke than common powder, and is less sensitive to dampness. According to the author of the recipe, (Mr. G. S. Melland, of London,) it may be completely preserved from the damp by applying to it a varnish of xyloidine, made by dissolving one part of paper in three parts of nitric acid, of density 1·040. By substituting the chromates of strontia, or other coloring matters, the experimenter will probably be able to reproduce those beautiful colored flames which attracted so much attention some time ago.

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Natural Colors in Photographs.—M. Poitevin presents to the Academy of Sciences, of Paris, the following process for photographing in colors: "Photographic paper being previously covered with a coat of violet subchloride of silver, obtained by the reduction by light of the white chloride in presence of a reducing salt, I apply to its surface a liquid formed by a mixture of one volume of a saturated so-

lution of bichromate of potassa, one volume of a saturated solution of sulphate of copper, and one volume of a solution of 5 per cent. of chloride of potassium. I allow the paper to dry, and keep it out of the light; it will remain good for use for several days. The bichromate is the principal agent, and may be replaced by chromic acid, but not advantageously; the sulphate of copper assists the action, and the chloride of potassium preserves the whites which are formed. For paintings on glass the exposure to light is only from five to ten minutes, and is proportional to the greater or less transparency of the color. The color may be watched as it comes. The paper is not yet sufficiently sensitive to be used in the camera; but colored images may be obtained on it in the enlarging apparatus. To preserve these pictures in an album, it is sufficient to wash them in water acidulated with chromic acid; then treat them with water containing bichloride of mercury, wash them in water charged with nitrate of lead, and then with water. After this preparation, they do not alter out of the light, but grow brown in the direct light of the sun."

M. Becquerel remarked that the colors were not quite as bright as those procured upon silver plates, and that especially the blues and violets were less decided; they were not more rapidly produced, nor more stable, but as they were more easily got, he regarded M. Poitevin's process as one of great *interest.*

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Work done in Rowing.—Prof. Haughton, of England, has applied the mechanical formulas to the determination of the work done by the crew of the Oxford prize-boat, eight in number, rowing their boat one mile in seven minutes, and finds the amount of work done to be 204·57 foot-tons, 28·07 foot-tons per man, or 4·01 per man per minute, and he remarks, "A good idea may be formed of the rate at which the muscles give out work in a boat race, from comparing this work with the average daily work of a laborer. At most kinds of labor there are 400 foot-tons of work accomplished in ten hours. In a boat race, the oarsman produces in one minute the hundredth part of his day's labor, and if he could continue to work at the same rate he could finish his day's task in one hour forty minutes, instead of the customary ten hours.

"The work done, therefore, in rowing one knot in seven minutes is, while it lasts, performed at a rate equal to *six times* that of a hard-worked laborer."

The memoranda of the editor of the *Journal* are also worth remembering. "We believe the foregoing to be one of the most probably accurate determinations of the few that have been made of the muscular force given out in rowing; and we agree with Professor Haughton in thinking that the comparison with the Oxford traction experiment is confimatory of his conclusions. In any case it fixes the limit of present presumable error at about 10 lbs. resistance, which, we apprehend, might disappear were the Oxford experiment repeated, and at a higher speed. The result, showing the great excess of labor for the unit

in time over and above that of an average day's work, is by no means startling, especially if reliance is to be placed upon the experiments of the late Mr. Robertson Buchanan, showing that in the following modes of applying muscular effort, rowing is the most advantageous of all others in the ratio of the annexed numbers:

Pumping	100
Turning winch	167
Bell ringing	227
Rowing	248

"The value of the investigation causes us the rather to desire that the actual resistance to traction of the Oxford race boat, loaded as with her crew, and *at her race speed*, should be experimentally ascertained.

"A good deal of valuable information, but very little known in England, on the subject of human force, and the relation between its absolute force or energy and the velocity with which it is given forth, and the time of its endurance, will be found in Bouguer, "Manœuvres des Vaisseaux," and in Euler's Memoirs in the Transactions of the Academy of St. Petersburg, new series, vol. ii. and vol. viii., in the last of which he examines the animal mechanics of rowing. Schultz's experiments, in the Memoirs of the Academy of Berlin, for 1783, also are probably the most complete that have ever been made upon human effort, and especially in reference to the relation (for a given form of muscular exertion) between height, weight, and absolute force in the man, and the result in work. This applies in a very direct way to the much debated question among oarsmen, as to what average size and weight of men in an eight-oar boat ought, *cæteris paribus*, to give the best results in speed. The Oxford view is, we believe, that heavy men (11 to 12 stone) give the best result, and this seems supported by the facts of their actual weights of crews and their general success. With heavy men especially, but, in fact, with men of all weights, there can be scarcely a doubt but that the proper proportioning the rate of stroke, so that the trunk of each man as it oscillates shall move as a pendulum pivoted on the hip-joints, and therefore with the least effort, and the right proportioning of the length of oars and all else, to give to the muscular effort expended *the fullest value at this rate*, has a by no means insensible effect upon the issue. A view which appears supported by the measured stroke of Oxford as against the quicker rate of Cambridge.

"Hachette, 'Traité des Machines,' and the late Mr. B. Bevin, C.E., have given also some important experimental results as to animal effort continued for long and short times, and Professor Leslie has placed on record some curious observations upon the subject. The sedan chairmen of the last century were accustomed to go along for perhaps half an hour, at the rate of 4 miles per hour, under a burden of 300 lbs., not always equally divided between them, and a case is recorded (how trustworthy we cannot say) of half a mile having been so done in five minutes and some seconds. For a short distance, say not more than 100 or 150 yards, the porters of Constantinople or the *fachines*

at Marseilles and other Mediterranean ports, do not refuse a burden of seven or eight hundred-weight carried on the back, with which, in a stooping posture, and sometimes aided by a staff in one hand, they travel at the rate of probably two miles per hour, if not faster."

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Electric-light Regulator.—The Committee of the Society for the Encouragement of National Industry, of Paris, having examined a new regulator submitted to them by M. Gaiffe, report that it is much simpler than any one in use, and requires no escapement apparatus. The carbon-holders are perfectly balanced and slide easily by friction rollers. The approach of the carbon is effected by means of a barrel and two wheels of unequal diameters which gear into the racks attached to the holders, this system being operated by an electro-magnet attracting the iron rod which terminates the lower holder. The helix of the magnet is wrapped in a peculiar way, so that when the lower carbon-holder is at the lowest part of its course, and has the feeblest attraction from the magnet, the magnetic action developed is a maximum. A peculiar arrangement also allows the luminous point to be centered without any change in the distance of the carbons. After experimenting upon this apparatus the Committee report:

1. That this regulator operates as regularly as the most perfect one in use.

2. That it is automatic; that is, it can light itself without requiring any previous separation of the carbons.

3. That it operates in any position and produces a luminous point in a constant position.

4. That in consequence of its position its manipulation is easy.

These advantages being joined to the power of adjusting the position of the luminous point and the cheapness of the apparatus, the Committee think the apparatus worthy of approval.

A drawing, showing the apparatus in detail, will be found in the report of the Society for February, 1866.

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Protection at Sea.—Another fearful disaster has for a moment excited the attention of the public, and shown travelers how insecure they are in entrusting themselves to the care of even well-reputed companies. The swamping at sea of the steamer *Evening Star* and consequent drowning of some two hundred passengers, of whom the larger part were women, must lead every one to inquire whether such accidents are unavoidable.

So far as we can judge, from the very reserved accounts which we have had of the accident, the steamer was caught in a violent cyclone, her rudder-chains jammed in the sheave of one of the pulleys, and she was thrown helpless into the trough of the sea, and either sprung a leak, or, as seems more possible, her hatch-coverings were swept away, and the sea, which was sweeping over her decks, poured into her cabins and hold, and carried her down. Of course, she was insufficiently supplied with boats, and they were useless, swamped in launching them,—

that appears to be the regular formula for a wreck at sea. But may we not inquire whether the officers of our passenger steamers, who are every week sailing with crowded cabins and steerage, are aware of the nature of the hurricane as it has been demonstrated by Espy, Redfield, Reed, and others, and of the rules for avoiding their severest shocks which have been given by Piddington, Blunt, and many others? The officers of our navy are familiar with them, as is evident by a report of this very storm made to the Navy Department by Lieutenant-Commander Gibson, U. S. steamer *Tohoma*, who seems to have saved his ship by attention to these rules. The captains of the British mail packets, who run to and through the West Indies, recognise and obey them, and thus shorten their voyage and diminish materially their expense and the danger of their passengers. Ought not the officers of our vessels, which run regularly along what is probably the most dangerous coast in the world, be required to be familiar with them and to observe them? The rules are simple, easily applied, and, so far as anything human can be, apparently infallible. Ought not, then, a commander of a passenger steamer to be dismissed for getting his ship into the heart of a hurricane? Again, is it impossible that a ship should be made unsinkable? If it be possible, no expense is too great for the security of the passenger. Now, it seems that, in this case at least, the steam syphon pumps, of which we hear much recently, would, in all probability, have saved the vessel. We know that they have been tried in our navy and successfully. Why should they not be required by law on board of all passenger ships? We published some years ago a plan proposed, if we remember right, by a Frenchman, which appears perfectly feasible and efficient against a leak. It consists in making all the rooms and compartments of the vessel approximately air-tight, when the doors are closed, and connecting them all with an air-pump, worked by the main or by the donkey engine. As the atmosphere corresponds to a column of water of more than 30 feet in height, it is very evident that a very small increase of the pressure in the room will drive the water out of the leak and allow access to it, so that it may either be stopped or the pressure maintained until the vessel reaches a port. But whatever may be said of individual propositions, there must certainly be means of increasing the safety of the passengers, and the government ought to seek them out and require their appliance. Why should not the National Academy of Sciences be engaged in examining this subject? Its charter by Congress apparently looked exactly to such employment. In the case of the *Evening Star* the shock of the disaster is increased by learning that she came very near meeting the same fate in the January trip, when the captain lost his life in his endeavors to save the vessel. On this occasion it seems that the passengers signed a statement warning passengers against the dangers they incurred owing to the manner in which the vessel was sent to sea, which statement was sent to the New York papers for publication, but refused by them; and even since the warning has been justified by the event, but one of the New York papers (the *Times*) has published this paper or made any allusion to it, so

entirely useless is our daily press as a safeguard against companies which advertise in their columns.

Since writing the above, we find the following in the New York *Tribune:*

"THE EVENING STAR DISASTER.—On Friday last the official investigation into the circumstances attending the loss of the *Evening Star* was concluded, and the report was forwarded to Washington. From the report it appears that the wreck was caused by an insufficiency of crew. Her entire crew numbered only ten men, four of whom were detailed as quartermasters, leaving the effective force only six. The evidence shows that she laid in the trough of the sea from 10 o'clock at night until 6 the next morning, and that no effort was made to get her head to the wind, though her rudder was intact for the most of this time, and jury masts could have been rigged. The water was often breast high on her decks, and passed into the hold through the hatchways and other apertures on the decks and sides. There was no carpenter on board to repair damages. The hull of the ship was staunch and tight; the engines were in perfect order; and, properly manned, the vessel could have lived through the cyclone, and carried her passengers into a port of safety."

Let us see now whether a rich company can commit manslaughter under the laws of this country.

New Galvanic Couple.—M. Mialaret-Becknell, of Louisiana, sends to the Academy of Sciences, of Paris, an account of a new galvanic battery invented by him. In a glass vessel, filled with a solution of hyposulphite of soda, is plunged a cylinder of copper. Within this cylinder is placed a porous cell, containing a solution of sulphate of copper in which is placed a sheet of copper bent in the form of an S. When the poles are connected, the cylinder of copper is gradually converted into sulphuret of copper, and the sheet in the porous cell is coated with galvanic copper. The residues furnished by the pile are sulphate of soda of no commercial value and sulphuret of copper, which, by simple roasting, is converted into sulphate and serves to feed the pile. He states that he used a battery of this kind with good effect during the rebellion, when it was impossible to obtain zinc.

Sodium Amalgamation.—The discovery of this process, which promises to prove a very valuable one, is claimed in this country by Mr. Wurtz, in England by Mr. Crookes. Mr. Wurtz's patent is considerably prior in date, and there is every reason for believing that his results were known in England before the date of Mr. Crookes' patent. It might also be considered a little awkward for Mr. C., that he had a similar dispute on the subject of the discovery of thallium, in which the French discoverer had considerably the best of the argument. All this would not have been worthy of notice, for it is not the first nor the hundredth time that English inventors have played this trick; but in an eulogistic notice of the process in the *Journal of the Society of Arts*, which takes no notice of Mr. Wurtz's claim, the editor cites the experiments of Prof. Silliman, which were made on Wurtz's invention. This is rather too hard to be borne.

New Process in Photography without the Aid of Light.—Mr. Hodgson, photographer, Sheffield, writes: "Last October the *Illustrated London News* issued a picture, along with the paper, of the 'Kingfisher's Haunt.' Having no use for it I put the picture in a drawer, between two sheets of paper prepared for enlarged photographs. The paper is prepared with 400 grains of isinglass, 440 grains of iodide of potassium, 146 grains of bromide of potassium, and 54 grains of chloride of sodium, to 40 ounces of water. This paper is quite insensitive to light; but what was my astonishment, on looking in the drawer last Tuesday, to find the paper on the top of the picture a negative, the sheet underneath a fine positive, the light greens and blues becoming white, and the reds becoming red, in the positive. Those pictures I hung in the light for two days, and they faded away. One sheet I have put under again, and several quires of blotting-paper on the top, and another positive is printing on the same paper, which I hope to be able to fix."—*Prac. Mec. Jour.*, August, 1865.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, October 19, 1866.

In the absence of the President and Vice-Presidents, Mr. Coleman Sellers was called upon, by motion, to take the chair, and the meeting being called to order, the minutes of the last meeting were read and approved.

The Board of Managers reported their minutes, and the following donations to the Library: From the Royal Society, the Royal Geographical Society, the Zoological Society, the Society of Arts, and the Institute of Civil Engineers, London, England; the Osterreichischen Ingenieur-Veriens, Vienna, Austria; the Canadian Government, Ottawa, Canada; Frederick Emmerick, Esq., Washington, D.C.; Benjamin Bannan, Esq., Pottsville, Pa.; and Thomas S. Fornon, Esq., Philadelphia.

The various Standing Committees reported their minutes, and the Special Committees reported progress.

The regular monthly report of the Resident Secretary on novelties in science and the mechanic arts was then read, as follows:

Secretary's Report.

ENGINEERING WORKS, &c.—Water supply of London.—We read, in the journal entitled *Engineering*, that surveys are in progress, with a view of diverting from the Severn the sewage of all the towns lying on that stream above Tewkesbury, and making arrangements for obtaining water from that place, carrying it to reservoirs, from which it might flow into London under high pressure.

The estimated cost of these works, made by Mr. Hamilton Fulton, is £3,000,000, ($15,000,000.)

From the same paper we learn that the five water companies now drawing their supply from the Thames offered to pay £1000 each, per year, if the sewage were diverted from all points of the river above

their sources of supply. This offer was made on occasion of the Thames Navigation Bill being brought before Parliament, and, though the plan was opposed by the Thames Commissioners, the amended bill was carried, and will go into operation *in two years.*

The Calcutta and South-eastern Railway, uniting the former place with the new port which is being established on the Mutlah River, has now nearly reached completion, as we learn from the journal above quoted. The two most interesting features in this work would seem to be, first, the bridge over Tolly's Canal, a single skew span of 128 feet, which was composed of two wrought iron girders, constructed on the shore, and put in place by supporting one end on a framework 24 feet high, erected in a cargo flat, and running the other out on wheels traveling on rails laid up to the abutment; second, the crossing of the Pyallee River, where the existing stream was filled up, and a new and straight channel cut and bridged.

The Victoria Bridge, over the Thames, at Battersea, has been widened by the addition of another bridge on independent foundations, but corresponding in profile with the old one, and finished on the outer side with the facings removed from the former, thus producing, in fact and appearance, a single bridge, with a total width of 132 feet, thus accommodating 7 lines of railroad, and leaving 33 feet available for platforms, &c. The details of construction are very different, however, in the new and old bridges, the girders being so arranged in the latter as to act like arches thrusting upon the piers, while in the former they are continuous, and exert only a vertical pressure, thus allowing the piers in this case to be built without the extension at the foundation required in the other. A full account of these and other points will be found in the August number of the *Mechanics' Magazine.*

The removal and replacement in a new position of the iron columns supporting a large cotton mill in Manchester, without interruption to the work of the establishment, was lately described in a paper read before the Institute of Civil Engineers by Mr. William Fairbairn.

The application of steam plows seems to have met with marked success in some parts of England, as we are informed by Mr. Edward Brown, who has just returned from a visit to that country.

In one village of Huntingdonshire two sets of apparatus for this work are in use, one of these being owned by a man who makes his living by its means, plowing with it at the price of £1 per acre.

In these cases two engines are used, one being placed on each side of the field, and each changing its place while the plows are being drawn over the field by the other. By this means much time is saved, and when the loss by friction, by wear of ropes, &c., involved in working with one engine and anchors is considered, there is found to be even a gain in economy of working.

Improvement in steel pens and pen-holders, by Geo. Stimpson, Jr., 37 Nassau St., New York. This improvement consists in a peculiar shape, by which great strength and elasticity is secured, and of a simple arrangement, by which a tongue-like blade is caused to

protrude from the holder, and thus at pleasure convert the ordinary into a fountain pen, while, by reason of the same arrangement, the pen can be cleaned with the greatest facility. Many specimens of writing, illustrating the capacities of these pens, were exhibited, and on trial the improvement showed itself to merit all that was claimed for it.

A new gas engine, by M. Pierre Hugon, of Paris, has been lately put in operation in London. We cannot see, from the description given, that it differs in anything but a few details of construction, from the engine of Lenoir. With an engine of 2½ horse power, it appears that about 74 cubic feet of gas are consumed per horse power per hour, or, at $3 per 1000 cubic feet, 21 cents per horse power per hour.

The steam syphon pump, a modification of the Giffard injector, seems to be performing very efficient work. The instrument in question consists of a globular vessel, into which, open from above, one, and from below two, large water pipes, in directions corresponding to those of the lines of an inverted letter Y, thus $\curlyvee$. Between the two lower branches enters a steam-pipe, which discharges steam upwards towards the other pipe. By this means water is drawn in through the two lower and expelled by the upper tube. The steam-pipe, curving around the ball, has given the name syphon to the arrangement.

Experiments with these pumps were lately made at the New York Navy Yard, by order of Commodore C. H. Bell, and the report thereupon was most favorable, as will be seen from the following extract:

The above data show that the syphon pump raises, in a given time, 41·7 per cent. more water than (the steam) pump having the same area of discharge, and in doing so consumes 48 per cent. more coal; therefore, in economy of fuel, the two kinds of pumps are nearly equal, but the syphon pump has superiority in the large bodies of water it can discharge in a given time, in its cost, in occupying less room in a vessel, in its not being liable to get out of order, its certainty of action, and unusual simplicity, there being no valves nor pistons to get deranged or choked by chips or dirt.

We unhesitatingly recommend it for relieving the holds of vessels from bilge water, and for discharging ashes from the fire-rooms.

We also recommend that the one now on board the Narraganset be retained and paid for.

Very respectfully, your obedient servants,

J. W. King, *Chief Eng., U.S.N.*
Thos. J. Jones, *Chief Eng., U.S.N.*
Geo. W. Stivers, *2d Asst. Eng., U.S.N.*

Commodore C. H. Bell, *U. S. N.*,
Commandant Navy Yard, New York.

PHYSICS.—Artificial stone, by Ransome's process. A large number of articles in this material were sent for exhibition by G. W. Norris, Esq. The process having been previously described in this journal, in quotations from foreign magazines, a brief notice only is here given. To the necessary quantity of clean dry sand, one-tenth part of concentrated solution of silicate of soda and one-tenth part of

pulverized flint is added, and the whole thoroughly commingled in a mixing mill. The soft material is then packed in moulds to give it the required shape, is taken out, "basted" with a solution of chloride of calcium, and boiled in a solution of the same, by which means a silicate of lime and chloride of sodium or common salt are formed in the stone by the double decomposition of the silicate of soda and chloride of calcium. The salt is then, in the last case, removed by a shower-bath applied for 12 hours, or more if necessary.

Specimens were exhibited of the material thus prepared, formed into vases, columns, ballistrades, ornaments in relief, such as heads, flowers, scrolls, &c., which showed remarkable delicacy and sharpness, and admirable strength, enduring heavy blows with an iron hammer.

This stone is to be largely employed in the construction of the grand hotel, Central Park, New York. The following certificate, made in the interest of the architects and constructors of this building, must carry much weight:

G. I. F. Bryant, Esq.

DEAR SIR: I have made an examination of "Ransome's Patent Concrete Stone," which you brought me, and find that its absorbent power for water, when treated first in vacuo and then under atmospheric pressure under water, is, on three trials, per cent:

15·65
15·70
16·04

8)47·39

mean of the 15·79 three trials.

Mr. T. H. Henry's sample gave 17 per cent. as the quantity of water absorbed; so the samples I operated upon are better than his. Since it is as firm as any sandstone used in this country, and possesses no more absorbent power, it seems to me to be suitable for any exposed ornamental work on buildings. Mr. Henry's test by sulphate of soda having shown no disintegration will take place from frost, I think you may safely adopt this cement stone in architecture, as you have proposed, for exterior as well as interior parts.

Respectfully, your obedient servant,

CHARLES T. JACKSON, M.D.,

State Assayer to Massachusetts.

N. B.—The length of time of immersion of my specimens in water, after the removal of air from the pores, was twenty-four hours.

Boston, March 13, 1866.

An article speaking in very strong terms of the excellence of this material will also be found in one of the late numbers of the *Engineer*, not to mention other articles which have before been published in most of the foreign magazines.

A new regulator for the electric lamp has been lately invented by M. A. Gaiffe, to whom a prize has been awarded by the Society for the Encouragement of National Industry. A report on

the subject by Du Moncel in the *Bulletin* of the Society, February, 1866, gives a full account of the apparatus in question. Its important feature is this, that the motion of the carbon points toward each other is not controlled by a fixed escapement, but by the action of an helix, which tends constantly to draw one of the poles into itself. By reason of this it is possible to adjust the position of the poles while the machine is in action without interruption, or the use of complicated machinery.

A process for staining wood, by Barton H. Jenks, with many specimens of its effects, was next described and exhibited. The wood to be treated is placed in a closed vessel, which is connected with an air-pump, and the air is removed. The coloring fluid is then allowed to enter and permeate the wood, which it does in a very thorough manner, on account of the removal of all air from the fibre. The excess of fluid is then pumped out, or the wood is removed and allowed to dry in the usual way. The specimens exhibited were all of white pine, and were stained with the following substances:

1. Nitrate of iron ..... Warm gray, light.
2. Nitrate of iron and paraffin ..... Warm gray, dark.
3. Sulphate of iron ..... Colder gray, light.
4. Sulphate of iron and paraffin ..... Colder gray, dark.
5. Sulphate of iron and logwood ..... Like 3.
6. Sulphate of iron, logwood, and paraffin ..... Like 2.
7. Chromate of potash ..... Yellow gray, light.
8. Chromate of potash and paraffin ..... Yellow gray, dark.
9. Bichromate of potash ..... Yellow gray, between 7 and 8.
10. Bichromate of potash and paraffin ..... Very rich yellow gray.
11. Logwood ..... Light orange.
12. Logwood and paraffin ..... Dark orange.
13. Aniline blue ..... Bluish slate.
14. Aniline blue and paraffin ..... Bluish slate, dark.
15. Aniline red ..... Violet with yellow shade.
16. Aniline red and paraffin ..... A little darker than 15.
17. Aniline solferino ..... Rich purple.
18. Aniline solferino and paraffin ..... Rich purple, darker.

The blocks exhibited were sections cut from larger sticks after treatent, and show the color to have penetrated very evenly and thoroughly.

Persistence of vision, in reference to the different colors of the spectrum, has been lately studied by the Abbé Laborde, who finds the more refrangible colors, such as blue, to be most persistent, and the others to be less so, red being the least.

Several instantaneous photographs, made by Mr. J. C. Browne, of Philadelphia, were then exhibited in the lantern. These pictures are remarkable for their perfect sharpness of definition and artistic effect. The light and shade in the clouds are such as an artist would select from his memory or imagination as best adapted to pictorial effect, while the moving objects, such as steamers crossing the view at full speed, sail-boats, figures, birds, and rippling waves, are given with a sharpness of outline and minute accuracy of detail which could not be surpassed in an ordinary sun-picture of a perfectly quiet object. These pictures are taken with the ordinary collodion. The instantan

eous production of the impression is obtained by the use of a large stop, by which much light is admitted to the lens. The aperture used in these pictures taken in the bright sunlight is, in fact, the same which would be employed for the subdued light of a room. In the latter case, an exposure of some 5 to 15 seconds would be required, while in the former the brighter light reduces it to a fraction of one second, or makes it practically instantaneous.

These facts are mentioned because there is a common, though false, impression that it is to some peculiar sensitiveness of the collodion that these instantaneous pictures owe their existence.

Several glass positives of the moon, made by Mr. Oscar G. Mason, of New York, from the world-famous positives of Mr. Rutherfurd, were likewise exhibited in the lantern. These positives are of unusual size, being 7 ins. in diameter, and some of them show portions of the lunar surface on a scale of 30 ins. to the moon's diameter.

These glass pictures were admirable in their sharpness, strength, and transparency, and their projections on the screen had all the beauty of porcelain maps in relief.

The Megascope, an old and almost forgotton instrument, for the projection of images from solid objects, was then exhibited by a very simple change in the arrangement of the lantern just used, involving no new parts; and the image of a hand was produced upon the screen of gigantic proportions, but with all the color, relief, and motion of life. Such arrangements as these are well adapted to the display of a few curious experiments, such as the above, but the great loss of light, and difficulty of obtaining anything like a flat field, renders them incompetent to compete with the common magic lantern for ordinary purposes.

CHEMISTRY.—A delicate test for nitric acid is supplied, as we learn from a paper by Mr. W. N. Hartly, in the *Chemical News*, by a simple galvanic combination, made up of a piece of platinum foil and a bit of magnesium wire. The foil is wrapped in ozone paper, (*i.e.* paper soaked in starch containing KI,) and a bit of magnesium wire is wound about this, being brought into contact with the platinum above the paper. This being dipped in the liquid to be tested, which has been slightly acidulated with sulphuric acid, peroxide of nitrogen was developed if any nitric acid was present in the solution, and stains the paper purple by the liberation of iodine.

The oxidizing power of the permanganates renders them, as is well known, very efficient deodorizers, but it is well to call attention at this time to their power as disinfectants. It appears, from experiments made by the Commissioners on the Cattle Plague, that these salts, added in small quantities to water containing injurious organic matter, completely destroy the same, and render the otherwise poisonous fluid wholesome. It must, however, be remembered that time is required for this action to be effected, and that without this element in the treatment, water may continue to hold the most injurious and disgust-impurities, even when strongly colored and unpleasantly flavored with the permanganate.

Mr. Coleman Sellers here remarked that the change of color produced by the action between permanganates and organic matter, afforded a valuable indication of its effect. Thus, a little of the red solution being added to offensive stagnant water lost its red color and assumed a green, being, in fact, reduced from a per-salt to a lower degree of oxidation, and that, therefore, the action should be continued, and an addition of the solution made until the red color was unaffected.

The deodorizing properties of these salts were very marked, and with this view they were frequently used by dentists in their practice; a solution whose color would hardly attract attention being very efficient in this respect.

Mr. R. Tighlman remarked that it was of great importance not to overlook the statement made in the Report of the Commissioners, already quoted by Prof. Crookes, that the mere addition of permanganate did not suffice to destroy animalcules or other organic germs, since many of these were shown by the microscope to exist in water strongly colored by the above salts. This was of importance, because an impression of security without foundation was otherwise given, which would lead to disasterous results, inducing people to use water with the disinfectant solution, under the impression that all must be right, when, in fact, it was in a most unwholesome and noxious state.

But if carbolic acid were first added and then permanganate, destruction of all organic matter must be accomplished.

Some remarkable statements concerning the deutoxide of hydrogen have been made by Schönbein in the *Journal für Praktische Chemie*. Thus, he states that the "solution may be concentrated by boiling," whereas it has been generally stated that this solution is decomposed explosively at 212° F. We also read that this compound may be completely dehydrated by evaporation under the air-pump, and that paper drenched with a solution containing but ½ per cent. may be dried, and will yet show the characteristic tests for this substance; results which would hardly be expected from the description of Thènards.

A new process for the manufacture of oxygen, lately patented in England, is described as follows: Oxychloride of copper is mixed with sand, or like material, to prevent it from vitreous fusion, and is then heated to redness in an earthen retort, when its oxygen is disengaged. It is then, on cooling, removed, broken into fragments, and exposed to the air for 12 hours, when it is found to be revivified or reoxygenated, and is ready to be again heated as before. Such a plan, if really successful, would be very valuable, but would require operations to be conducted on the large scale to realize its advantages. This has seemed to be the drawback to the similar process in which binoxide of barium is first reduced by heating in a current of steam, and then reoxidized by a current of air, and which never appears to have been practically developed, though recommended by very high authorities.

A paper on flame reactions, by Bunsen, has been translated by Prof. Roscoe, and published in the last number of the *Philosophical Magazine*. From this it would appear that all ordinary blow-pipe reactions may be shown with the best effect and great convenience by

the use of a Bunsen burner properly constructed. For the details of the burner and its applications, we must refer to the the original paper, or to an abstract of the same in the August number of the *Mechanics' Magazine*, page 67.

Phosphorus may be removed from iron, as is stated by Carl H. L. Wintzer, of Hanover, if chloride of calcium is added to the metal while on the hearth of the puddling furnace. A chloride of phosphorus is then formed, which, by reason of its volatility, quickly leaves the other materials, and the lime fluxes with silicious matters.

The deposits of cubic nitre, or nitrate of soda, generally supposed to exist in Chili, but really found in Peru, are very fully described by Mr. David Forbes, in a paper upon Peruvian minerals, published in the *Philosophical Magazine*. These deposits occur along what seem to be the shores of an ancient chain of shallow and very irregular lakes, which are now perfectly dry, barren, and desert. This deposit is found only along the shores, the central parts containing only sea salt. This suggests and substantiates the conjecture that they are the result of decomposition, under peculiar conditions, of the marine vegetation which must formerly have lined these shores. Even the land growth must at one time have been most luxuriant, for ancient wood is found in such quantity in this locality that until lately it was the only fuel used in refining the salt, and is yet largely employed for this purpose.

At the conclusion of the Secretary's Report, Mr. Nystrom made the following remarks on a composition of cast iron and steel, and also on the heating of journals in propeller engines:

Mr. President: I have read in an English journal an article relating to a composition of cast iron and Bessemer steel, said to produce a hard metal, and used for casting steam cylinders. A few years ago, when experimenting in the pneumatic process of refining iron, I produced similar compositions, of which here is a specimen. My object was to produce a tough metal for casting guns, and I found that different proportions of cast iron and pneumatic steel gave different grades of toughness and hardness. About one part of steel to three of cast iron I thought would be the best proportion for guns. I stated the case to some functionaries in the Navy Department about four years ago, but did not succeed to impress upon them its importance. This specimen contains about half cast iron and half steel—it is so hard that it cannot be cut by any steel tool. Its specific gravity is 7·56, which is nearer wrought iron (7·78) than that of cast iron, (7·20.)

This specimen is a piece of a lid for a blast-pipe, in which it was intended to drill some holes, but was found so hard that the hardest cast steel drill did not touch it in the least. I then annealed it in a charcoal fire for twenty-four hours, and let it cool very slow and gradually, by which the toughness was considerably increased, but the hardness remained nearly the same as before, so that I still could not drill the holes, but was obliged to cast another lid of the same cast iron without steel.

This composition can be advantageously used for a great many purposes in the mechanic arts, as for steam cylinders, packing-rings for steam pistons, slide-valves, guides, and tool-slides, rollers for hard metals, grist-mills, guns, face-plates, and wherever a hard and tough metal is required. When the composition is made as hard as this specimen, it cannot be cut by steel tools, but if the object is not too complicated it can, in many cases, be ground to a true surface by sandstone and emery.

I believe this composition can remove a great difficulty involving millions of dollars in this country, namely, the heating of journals in propeller engines, which now controls, to a great extent, the success of that machinery.

In order to overcome this difficulty, Chief Engineer Isherwood has introduced very long journals, from two to three times the usual proportions, which would apparently lead to satisfaction, but experience has not fully realized the expected result, and upon reflection we are able to trace the difficulty attending the long journal, namely, to keep the bearing surfaces in proper contact and perfectly concentric.

The greatest difficulty appears to be in the crank-pin journal, where the space is generally so crowded that the desired length cannot be obtained, but if fitted with boxes of this composition of cast iron and steel, I believe the difficulty would be overcome.

The heating is occasioned by excessive pressure and velocity in the journal surfaces (dynamic momentum) necessary in the short stroke direct action propeller engines. When the journals begin to heat, the iron beds itself into the box, crushes its texture, and excludes all lubricating substance from the surfaces in contact, so that even if the journal was wholly immersed in oil, the heating could not be prevented, but sometimes becomes so strong as to actually melt the metal, which could not be the case with this composition.

The cast iron and steel boxes should necessarily be carefully ground and fitted on the journal; and, in order to secure a perfect bearing in the whole length, it should also be spherically fitted in the stub end.

For the main journals it would not answer to fit cast iron and steel boxes as the brasses are now fitted. The cast iron and steel boxes should be fitted spherically in the plumber-blocks, and if properly executed there would be no trouble of heating. The length of the journal should be made equal to or not more than $1\frac{1}{4}$ times its diameter.

Another serious obstacle for preventing the heating of journals is the difficulty of procuring a uniform iron in the forging of a crank-shaft or crank-pin. The pneumatic process of refining iron known as "Bessemer's," by which ingots can be cast into a homogeneous mass, may fully remove that difficulty, and it is very satisfactory to know that we are now able to procure such castings in this country, as seen in the advertisements of the Albany Iron Works, Troy, N.Y., where it appears the Bessemer process is now brought to a successful operation.

In our present trouble we are often obliged to slack the speed of the propeller engine for heating of journals, which proved a serious

hamstring during the war, in chasing blockade-runners, which were often lost on that account.

The excessive dynamic momentum to which the cranking journal is subjected in propeller engines, can be sustained better by cast iron than by brass, for the following reasons:

PROPERTIES OF—	Cast iron and steel.	Brass.
Crushing weight in tons per square inch	125	63
Expansion per unit of heat	618	1040
Conducting power for heat	300	700
Specific heat	120	93
Smelting point	2900°	1900°
Cost per weight	1	10

All these data are in favor of cast iron and steel for sustaining great dynamic momentums in journals. It should be clearly distinguished between the dynamic momentum acting to heat the journal and that transmitted through the propeller-shaft, as they bear no fixed proportions.

The cast iron and steel can sustain double the crushing weight, and is twice as hard as brass, but this fact does not constitute the superiority of the former over the latter, for a brass composition can be produced which is as hard as steel, and sometimes used for dies; but the advantage of cast iron lies in its uniformity of texture, even if made of the same hardness as brass.

The expansion by heat throws the box and its bearing surface out of shape, which evil is greater in brass than in cast iron and steel, and the uneven texture in brass makes some parts expand more than others, by which projections are raised in the wearing-surface which start the cutting of the journal.

The conducting power stores the heat in the box, and renders the brass sooner heated than by cast iron and steel.

The specific heat resists the temperature of the box; that is to say, it requires more dynamic momentum, or more units of heat, to produce a certain temperature in cast iron and steel than in brass.

The work converted into heat in the brass boxes will, to a great extent, be transmitted through the cast iron and steel boxes to, and utilized by, the propeller.

The friction in cast iron and steel boxes would be considerably less than that in brass or Babbitt's metal.

The difficulties about the cast iron and steel boxes would be that they require a more careful fitting on the journal at the outset, and that they are liable to rust when the engine is at rest. But a careful engineer will overcome these difficulties.

Mr. Washington Jones remarked that "there is no difficulty about heating of the journals. Sometimes they heat and sometimes not. It is only required to make the bearing-surfaces sufficiently large for the pressure."

Mr. Coleman Sellers remarked that "cast iron bearings work very well, and perhaps better than brass."

The meeting was then, on motion, adjourned.

HENRY MORTON, *Secretary.*

BIBLIOGRAPHICAL NOTICES.

Canada Geological Survey.

The library of the Franklin Institute is indebted to the provincial government of Canada for a copy of the atlas of maps and sections intended to accompany the volume on the Geology of Canada, which appeared in 1863. It consists of five colored maps, with accompanying sections, intended to illustrate the arrangement of the Canada rocks, and their connexions with the formations in the United States. Although the general maps are on a very small scale, yet the great precision of their execution, and the careful manner in which they are printed, render them better for reference than larger and more pretentious maps, in which these good qualities are not found. The extreme care which has been taken to obtain the best possible information from the most authentic sources, and the high reputation which the survey has made for itself by its accuracy, render the work to which this is an appendage one of the most valuable aids to the geologist.

Coal, Iron, and Oil; or, the Practical American Miner. By JAMES HARRIES DADDOW and BENJAMIN BANNAN. Pottsville: Bannan, 1866. 8 vo., pages 808. Maps.

This is a very valuable work, presenting in an interesting form a great amount of information on the subject of the coal, iron, and oil mines of the United States and elsewhere, and giving at the same time both a practical and theoretical treatise on the subject of their formation, occurrence, and method of working. It is well illustrated by cuts, presenting views, diagrams, and sections, and contains a large and apparently excellent map of the anthracite districts of Pennsylvania. The principal author of the work (Mr. Daddow), in his preface, asks especial attention to his three new theoretical propositions, which are—

"1. That the material forming both the Azoic and Palœozoic formations of the earth are almost exclusively and directly from volcanic sources.

"2. That volcanic and subterranean heat produced the vapors or gases which resulted in petroleum, naphtha, &c.

"3. That the hydrocarbons, in the shape of naphtha, petroleum, and their resulting bitumen, formed mineral coal."

We do not think any good observer, after carefully examining our rocks, will be disposed to agree with the authors in any one of these propositions, but cannot here go into the arguments to show the contrary. All we can say is, that, supposing these theoretical propositions to be wrong, they detract but slightly from the great value which the care and industry of the authors have given to the work.